UNIVERSITY OF AUCKLAND
Waipapa Taumata Rau
NEW ZEALAND

国家留学基金管理委员会
CHINA SCHOLARSHIP COUNCIL

PhD Opportunities

A selection of some of the projects and supervisors currently available for new China Scholarship Council applicants

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AUCKLAND BIOENGINEERING INSTITUTE

Using agent-based modelling to understand how structural characteristics affect endometriotic lesion dynamics

Agent-based models are a powerful mathematical tool to understand how both individual cell behaviours, and behaviours at different time and space scales, impact biological tissue function. However, many of the current models do not explicitly account for key architectural characteristics of the cell or tissue. For example, anisotropy in shape and mechanics of smooth muscle cells, or cell interactions with vascular and collagen networks. With the increasing quality of biological imaging data in recent years comes an increase in the detail on these morphologies. Such characteristics can be influential on both cell and tissue dynamics. The particular applications of interest for this project are endometrial tissue and endometriotic lesions.

This project aims to: Use agent-based models to understand how structural characteristics affect model results; Create a workflow to import imaging data from endometrial sections and endometriotic lesion imaging into an agent-based modelling framework; Identify cell and tissue architectural characteristics of interest; Develop methods to include evident structural characteristics in agent-based models.

Desired skills: Bachelors or Masters degree in engineering, applied mathematics, or equivalent. Strong background in image analysis and/or computational modelling.

Contact: Dr Claire Miller/Dr Alys Clark, alys.clark@auckland.ac.nz

Electrophysiology of menstruation; a multiscale modelling approach

Contractions of the uterus vary during the different phases of the menstrual cycle. These contractions are thought to facilitate transport of sperm for egg fertilisation during the late follicular phase and to aid the menstruation process during menses. These contractions can be a cause of pain during menses. Abnormalities in uterine contractions have been hypothesised to contribute to retrograde menstruation: the loss of menstrual debris out of the fallopian tube. Retrograde menstruation, in turn, is thought to be the root cause of endometriosis: a chronic disease affecting 1 in 9 women, in which lesions form when endometrial-like cells grow outside the uterus.

This project aims to: Develop mathematical models for the activation of contractions in smooth muscle tissue of the uterus; Model cell contraction within a tissue using agent-

based modelling approaches, and explore the relationship between agent-based model results and continuum models of electrical patterns in the uterus; Use the models to investigate normal and abnormal contractions in the uterus; Stretch goal: model the interaction between contractions and menstrual fluid.

Contact: Dr Claire Miller/Dr Alys Clark, alys.clark@auckland.ac.nz

A storm in the brain - analysing brain network disruptions after mild traumatic brain injury

Mild Traumatic brain injury (mTBI) is a major health challenge which is difficult to diagnose and treat. The major conundrum in mTBI research is that there is often no relationship between the location or extent of the injuries and subsequent symptoms. This project seeks to find the missing link between the brain's functional deficits and structural damage after mTBI. Our focus is on brain vascular damage, which has not received much attention. Specifically, we will investigate the role of brain vascular cells called pericytes on: 1) how it causes local brain vascular damage; 2) how this is later expressed as functional deficits after mTBI. This will be done by developing an experimentally informed multiscale model of the brain connectivity network that can link localised damages in the brain with global functional deficits. We will use our own mTBI dataset that we collected with rugby players from Gisborne to develop and validate the model. We will also perform in-vitro cell experiments with human brain cells to characterise which key cellular pathways are involved in pericyte-mediated vascular damage. This will inform our brain network connectivity model to find the link between structural damage and functional deficits, for the first time.

Contact: Dr Vickie Shim, v.shim@auckland.ac.nz

Strains on the fetal heart during development

When a baby does not reach its growth potential in its mother's womb, it can have lifelong health consequences, including an increased risk of cardiac disease. The condition, known as fetal growth restriction, has been shown to be associated with poor placental vascular development. As the placenta supplies oxygen to the developing fetus, its form and function is critical for healthy development. The interaction between the placenta and the fetal circulation is likely to play an important role, both in the short term growth of the baby, and in determining health in later life. However, the interactions between placental and fetal circulations are poorly understood. We have developed computational models that suggest placental blood vessel structure typical of fetal growth restriction are sufficiently high resistance to impact on the function of the fetal heart. In this project you will take this concept further and develop a computational model of the fetal cardiovascular system that can predict if changes in placental resistance and oxygen delivery to the fetus could result in sustained alterations in fetal cardiac function during pregnancy. The project will suit students with a background in areas such as Biomedical Engineering, Engineering Science, Maths, or Physics with an interest in computational modelling and biological applications. Programming experience, particularly with python, is preferred.

Contact: Dr Alys Clark, alys.clark@auckland.ac.nz

Decodification of brain activity via deep learning and modelling techniques
Head-mounted miniaturised microscopes (miniscopes) enable brain activity to be recorded in freely moving rodents. By using miniscopes, we can directly decipher how brain cell activity underlies behaviour as it happens in the awake behaving animal. This project aims to use deep learning techniques to decode brain activity patterns while studying the underlying neuronal connectivity using an inverse modelling approach. We are examining the cellular mechanisms that underlie behavioural deficits in mouse models of Autism Spectrum Disorders (ASD) and Alzheimer's disease (AD). We utilise miniscopes to examine cellular activity in the hippocampus during spatial memory tasks. The hippocampus contains place cells which display location-specific firing to encode spatial environments and are important for spatial memory. With the developed methodologies of this project, we will be able to decode mouse position and velocity. We predict that deficits in decoding will correlate with spatial memory impairments. We are looking for highly motivated students with a physics, engineering, or mathematics background, prior programming experience (ideally Python) and a strong interest in microscopy, image analysis, deep learning and neuroscience.

Contact: Dr Gonzalo Maso Talou, g.masotalou@auckland.ac.nz

Dr Jamie Gillen from Global Studies is interested in supervising students with projects relating to China's political and cultural relationship to Southeast Asia, particularly Vietnam and mainland Southeast Asia.
Contact: Dr Jamie Gillen, jamie.gillen@auckland.ac.nz

Dr Karen Huang from Asian Studies/Chinese is looking to supervise students with research topics relating to Chinese dialects, minority languages in China, or sociolinguistic issues in Chinese speaking areas.
Contact: Dr Karen Huang, k.huang@auckland.ac.nz

Dr Danping Wang from Asian Studies/Chinese is interested in supervising the following topics: Teaching and learning Chinese in contentious geopolitical contexts; Multimodality and technology in Chinese language teaching; Decolonising approaches in language education; and translanguaging perspectives on teaching Chinese as a heritage and foreign language.
Contact: Dr Danping Wang, danping.wang@auckland.ac.nz

Dr Changzoo Song from Asian Studies/Korean has research interests in: diasporic identities (of Koreans including the Chaoxianzu Koreans in China, Soviet Koreans, and Zainichi in Japan); nationalism (including cyber-nationalism) in South Korea and China; Korean diasporic culinary cultures and practices; and integration and identity issues of Asian migrants in New Zealand.
Contact: Dr Changzoo Song, ch.song@auckland.ac.nz

Dr Ellen Nakamura from Asian Studies/Japanese is interested in research topics that cover Japanese history, gender history, or family history.
Contact: Dr Ellen Nakamura, e.nakamura@auckland.ac.nz

Dr Mi Yung Park from Asian Studies/Korean is interested in learning/teaching Korean as a foreign language in China; Korean language learning and identity among Chinese international students in Korea; Family language policy and heritage language maintenance among (mixed) Korean migrant families in China; Multilingualism and heritage language maintenance among (mixed) Asian migrant families in Korea (or in New Zealand).
Contact: Dr Mi Yung Park, my.park@auckland.ac.nz

Dr Bing Xiong from Communication is interested in research projects related to social media in rural China; Chinese internet and politics; Chinese public discourse; Digital culture and communication; intercultural communication/Asian communication theory.
Contact: Dr Bingjuan Xiong, bingjuan.xiong@auckland.ac.nz

Dr Louisa Buckingham from Applied Linguistics is interested in sociolinguistics, corpus-informed discourse analysis, language and technology.
Contact: Dr Louisa Buckingham, l.buckingham@auckland.ac.nz

Dr Sunhee Koo from Anthropology is interested in the construction and negotiation of identities in East Asia (China, Korea and Japan). This year, Sunhee published: Sound of the Border - Music and Identity of Korean Minority. She is keen to supervise PhD students who work on topics in East Asia (expressive cultures, popular/traditional music, and dances) and issues of identity, transnationalism, diaspora, migration, politics, and agency.
Contact: Dr Sunhee Koo, s.koo@auckland.ac.nz

Associate Professor Katherine Smits from Politics and International Relations is interested in supervising these areas: Multiculturalism and policies towards ethno-cultural minorities; Nationalism, politics of national identity; Political participation, deliberation, practices of citizenship.
Contact: Associate Professor Katherine Smits, k.smits@auckland.ac.nz

Dr Stephen Noakes from Politics and International Relations is interested in supervising these areas Chinese political economy, civil society/NGOs, Chinese diaspora/transnational organisations, foreign development aid, or anything with a focus on PRC-relations with Pacific Island countries or the 5 Eyes security partners.
Contact: Dr Stephen Noakes, s.noakes@auckland.ac.nz

Associate Professor Neal Curtis from Media and Communication is interested to supervise students working on political or cultural aspects of Chinese social media. He is also a comics studies scholar and would welcome any students interested in developing a thesis on Chinese *manhua*, especially their history or role in either communication, propaganda or cultural change.
Contact: Associate Professor Neal Curtis, n.curtis@auckland.ac.nz

Associate Professor Nabeel Zuberi from Media and Communication has possible supervision areas in: Popular Music and Media Cultures, Technologies and Industries; Sound Studies; Nationalisms, Transnationalisms and Diasporas in Film, Media and Cultural Studies; Race, Racism, Racialisation and Media; Muslims and Media; South Asian Media; Black Media and Cultural Studies; Media, Film, Television, Communication.
Contact: Associate Professor Nabeel Zuberi, n.zuberi@auckland.ac.nz

Dr Nicole Perry from German Studies/Comparative Literature is interested in supervising students with an interest in Chinese/German relationships. She will also consider students interested in studying postcolonial topics including North American and South Pacific Indigenous Studies.
Contact: Dr Nicole Perry, nicole.perry@auckland.ac.nz

Dr Norbert Vanek from Applied Linguistics is interested in supervising these areas: Bilingualism and thought, Cross-linguistic influence in second language acquisition, Event structure, Linguistic relativity, Reference to time/space/person/negation in L2, Linguistic modulations in learning cognitive categories.
Contact: Dr Norbert Vanek, norbert.vanek@auckland.ac.nz

Associate Professor Tan Bee Tin from Applied Linguistics is interested in supervising students in sociolinguistics, the role of interest and creativity in language teaching, materials development and evaluation, teaching English in Asian contexts.
Contact: Associate Professor Tan Bee Tin, tb.tin@auckland.ac.nz

Associate Professor Jennifer Lees-Marshment is an expert in political marketing, political communication, political management and elections. She can supervise topics such as how New Zealand parties target Chinese New Zealander voters, Chinese politicians use of political marketing and communication tools and Chinese nation branding.
Contact: Associate Professor Jennifer Lees-Marshment, j.lees-marshment@auckland.ac.nz

Associate Professor Jeremy Armstrong in Classical Studies and Ancient History is interested in supervising projects related to state-formation, urbanization, politics, and/or warfare across the ancient Mediterranean basin during the first millennium BCE, particularly in the Italian peninsula. Other areas of interest include the movement/transfer of technology, as well as cultural interaction and exchange, in the ancient Mediterranean world.
Contact: Associate Professor Jeremy Armstrong, js.armstrong@auckland.ac.nz

Associate Professor Lisa Bailey in Classical Studies and Ancient History is interested in supervising topics in late antique and early medieval history, especially those connected to religious, gender, or social history. She is currently working on a project related to the history of slaves in the early medieval church.
Contact: Associate Professor Lisa Bailey, lk.bailey@auckland.ac.nz

Professor Malcolm Campbell publishes and supervises theses in the fields of Australian history, Irish history, the history of migration and the history of the British empire. His most recent book examines Irish migration and settlement in the Pacific world, including East Asia.
Contact: Professor Malcolm Campbell, mc.campbell@auckland.ac.nz

Dr Maxine Lewis is Senior Lecturer in Classical Studies and Ancient History. Maxine is available to supervise projects in four main areas: Latin literature; space and place in the Roman world; gender, women, and sexuality in ancient Rome and Greece; and the reception of Greek and Latin literature in later periods.
Contact: Dr Maxine Lewis, maxine.lewis@auckland.ac.nz

Associate Professor Xuelin Zhou in Media and Screen, is interested in supervising research that focuses on comparative film studies, East Asian popular culture and especially Chinese-language film. He has published in these areas both in English and in Chinese.
Contact: Associate Professor Xuelin Zhou, x.zhou@auckland.ac.nz

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BUSINESS SCHOOL

"How does a walkable neighbourhood shape the built environment" is a research programme that proposes to "connect the dots" regarding neighbourhood effects on the housing market and people's well-being. Walkability - a measure of how friendly an area is to walk in - is vital to the modern built environment and a key consideration in the housing market. Walkability enables age-friendly, child-friendly, and disability-friendly access to neighbourhood amenities and public spaces, particularly those without private transport. Thus, enabling a walkable neighbourhood can alleviate social exclusion, improve health via physical activities, enhance people's experience and satisfaction in higher density-built environments, mitigate pollution by reducing car usage and improve housing affordability by saving transport costs. Consequently, a walkable neighbourhood can improve sociability through pedestrian encounters, and it is imperative for urban design to enhance urban vitality and improve accessibility for a built environment.

Contact: Dr William Cheung, william.cheung@auckland.ac.nz

Employing Digital Technologies in Managing Customer and Employee Experiences

Associate Professor Laszlo Sajtos leads the Digital Technologies Research Lab that focuses on examining the role of digital technologies (AI, IoT, platforms) in managing customer and employee experience in service interactions. Currently we have projects related to using autonomous technologies (cars, robots and chatbots) in healthcare, education and hospitality settings.

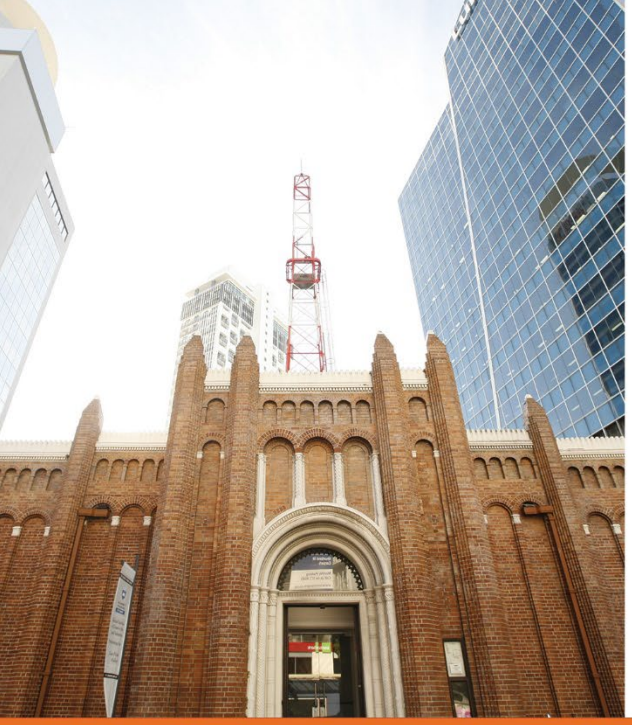
Contact: Associate Professor Laszlo Sajtos, l.sajtos@auckland.ac.nz

Chinese cultural influences on Food Waste

One third of the food produced for human consumption every year is wasted. On one hand, Chinese families are supposed to be generous hosts, and on the other hand, there is a growing imperative to consume food more sustainably. There is an opportunity to ethnographically study (via interviews, observations and participation) how Chinese people feel about, and manage food waste at major cultural events such as more private Lunar New Year Family dinners, or more public weddings.

The ideal candidate for this project should be fluent in Mandarin and English and be interested in developing their expertise in qualitative research methods (some expertise will be highly beneficial, but advanced training will be provided if required). This research could be carried out in China and/or New Zealand.

Contact: Associate Professor Karen V. Fernandez, k.fernandez@auckland.ac.nz



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CREATIVE ARTS AND INDUSTRIES

School of Architecture and Planning

Wealth and the Built Environment: Social and Environmental Impacts
Wealth accumulation and unequal distribution between and within countries are global concerns. The unfair distribution and consumption of resources keep widening inequality gaps and their effects on the environment. The built environment has historically been used as storage of wealth and speculation. However, the link between wealth and the built environment remains highly unexplored. This project will investigate the accumulation of wealth in the built environment and its impact on social and ecological systems. This research project will use the theory of collapse and resilience to describe, map, and analyse the impact of wealth on the built environment. Further research is required to contextualise the knowledge emerging from the following questions: 1) How are wealth and the built environment linked? 2) To what extent does wealth accumulation in the built environment negatively impact social and environmental systems? 3) What are the impacts of wealth on the education, practice, production, and consumption of architecture?

Contact: Dr Emilio Garcia, e.garcia@auckland.ac.nz

Architectural History & Heritage Conservation
Opportunities are available for those interested in architectural history, particularly histories of modern and postmodern architecture, New Zealand architecture, and architectural education. There are also opportunities available for those interested in the history and theory of architectural heritage conservation, including but not limited to modern heritage and historic areas.

Contact: Associate Professor Julia Gatley, julia.gatley@auckland.ac.nz

Urban Morphology, Politics of Urbanism and Spatial justice in China and New Zealand
At the School of Architecture and Planning, established and emerging supervisors invite applications from driven students to commence PhD research projects that focus on:

1) Urban morphology and design: exploring the spatial logic of urban development
2) The politics of planning reforms in China and New Zealand: a comparison
3) Spatial justice and urban development: multi-scale spatial master-planning for equity, democracy and participation
4) Emerging spatial patterns: from multi-scalar to trans-scalar urban development.

Contact: Dr I-Ting Chuang, iting.chuang@auckland.ac.nz
Associate Professor Kai Gu, k.gu@auckland.ac.nz
Associate Professor Manfredo Manfredini, m.manfredini@auckland.ac.nz

Sustainability and Built Environment
The Future Cities Research Hub brings together researchers at the School of Architecture and Planning of the University of Auckland, addressing different disciplines concerned with the built environment and their multiple interfaces with the natural environment. The aim of the Hub is to better understand the complexities of cities across the building, neighbourhood and urban scales as well as the challenges of ecosystems during and after urbanisation, in order to find innovative solutions to address built and natural environments challenges and contributing to the achievement of national, regional and global sustainable development goals. Students interested in topics including sustainable architecture, regenerative design, adaptive reuse and heritage conservation, post-occupancy evaluation, advanced façade design and responsive architecture, architectural science and technology, are welcome to contact:

Associate Professor Paola Boarin, p.boarin@auckland.ac.nz
Dr Alessandro Premier, alessandro.premier@auckland.ac.nz
Dr Ferdinand Oswald, ferdinand.oswald@auckland.ac.nz

ELAM School of Fine Arts

Design for Sustainability, Industrial Design & Design anthropology
Candidates interested in topics including: Practice-based design research with specific focus on sustainable innovation to regenerate complex social, technical and ecological systems; Pluriversal design with interest in development, the global South, inequality, indigenous knowledge and decolonisation; Local futures, including appropriate technology, circular economies, and food systems; Socio-technical innovation for industrial design; and the applied contexts of design thinking in organisational settings are welcome to contact:

Dr Angus Campbell, angus.campbell@auckland.ac.nz
Dr Diana Albarran Gonzalez, d.albarran@auckland.ac.nz

School of Dance

Dance and Social inclusion
Candidates interested in Dance, Social Inclusion, Wellbeing, Critical Theory, particularly in investigations of collaboration, creativity, dance, community, higher education, indigenous perspectives, politics and social inclusion are welcome to contact:

Professor Nicholas Rowe, n.rowe@auckland.ac.nz
Associate Professor Ralph Buck, r.buck@auckland.ac.nz
Dr Becca Webber, b.weber@auckland.ac.nz

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EDUCATION AND SOCIAL WORK

Sport Sociology and Sports Media
Opportunities are available for those interested in social science research on sport, sports media, and women's sport. Professor Bruce is a former news and sports journalist whose current projects analyse representations of the Paralympic Games, netball and women's sport, and the meaning of netball and Rugby World Cups to fans.

Contact: Professor Toni Bruce, t.bruce@auckland.ac.nz

Thriving oral languages and literacies of young children within their family, community and school cultures
Professor Janet Gaffney is interested in supervising the research of educators with teaching experience in early childhood and the primary years, who strive to understand the linguistic, cultural and social knowledges and ways of being, of children and their families, which are the foundation of relational and respectful learning and teaching. Oral languages is intentionally plural to be inclusive of heritage languages. Literacies is broadly defined to encompass all forms of expression (arts, facial expressions, gestures, songs, movement, dance, signs), in addition to reading, writing and oral communication.

Contact: Professor Janet S. Gaffney, janet.gaffney@auckland.ac.nz
Director Te Puna Reo Pohewa | The Marie Clay Research Centre

Critical thinking within classroom talk
Opportunities are available for those interested in classroom talk within the sectors of primary or secondary schools, in particular classroom talk that includes critical thinking. You may wish to specialise within the broad subject of classroom talk such as investigating dialogic talk; different cultural perspectives of critical thinking; conspiracy theories and fake news; developmental aspects related to adolescence and curriculum specific classroom talk. You may be interested in either face to face classroom talk, online talk or a blended approach.

Contact: Dr Maree Davies, mj.davies@auckland.ac.nz

Early Childhood Education and Childhood Studies
Seeking candidates interested in PhD studies in early childhood education (birth to 8) or childhood studies (birth to 18) within the transdisciplinary framework of the Centre for Global Childhoods. Particularly of interest are projects that relate to contemporary global issues of children and childhoods, and that are considering utilising posthuman and new materialist methodologies, but other theoretical and philosophical, qualitative or mixed-methods studies are also accepted.

Contact: Professor Marek Tesar, m.tesar@auckland.ac.nz
Director, Centre for Global Childhoods

Cognitive and Socio-psychological Factors in Learning and Teaching L2 Writing
Opportunities are available for those interested in examining issues relating to the teaching and learning of second or foreign languages, particularly the teaching of English to speakers of other languages (TESOL), which is broadly grouped into the field of applied linguistics. Those interested in foreign or second language writing, whose focuses are on learner individual differences in relation to teacher and peer written feedback, academic literacy, and pedagogical intervention for improving L2 writing and related teacher education efficacy, are particularly welcome to apply.

Contact: Professor Lawrence Zhang, lj.zhang@auckland.ac.nz

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ENGINEERING

Civil and Environmental Engineering

Automated infrastructure inspection and management

Over the past years, I have explored the use of Building Information Modelling (BIM), Digital Twins (DTs), Unmanned Aerial Systems (UAS), Artificial Intelligence (AI) for automated and smart inspection and management of buildings, bridges and other infrastructure systems. Future research will focus on devising new automation methods to reduce human interventions and improve safety outcomes for structural inspection and making AI-based automated structural assessment more efficient and reliable.

The CSC-funded PhD students will be part of a recently established Infrastructure Intelligence Group (IIG) which has 6 academic staff members (specialising in DTs, BIM, robotics, AI, simulation, structures, computer science) and a number of existing PhD students. The new PhD students can leverage our cutting-edge research facilities (e.g. UAS, BIM tools, 3D Laser Scanners, LiDAR sensors, VR/AR glasses, high-performance computers, motion sensing systems, robotic systems) as part of the Smart Digital Lab and the Trimble Technology Lab.

Main supervisor: Dr Yang Zou, yang.zou@auckland.ac.nz

Future earthquake-resistant structures

In conventional design, structures are designed with the assumption that the base is fixed at the structural support. In reality, structures are supported by the ground with different stiffness. Consequently, the design of fixed-base structures does not reflect reality. During earthquakes, the properties and spatial development of the ground along the propagation path of the seismic waves also affect the ground motions and thus the response of the structures. In addition, the influence of the adjacent structures on the structure of focus cannot be considered with the fixed-base assumption. Therefore, to design the structure realistically, the effects of the soil on the structures and the ground motions are considered in this research to have resilient earthquake-resistant structures in the future.

Main Supervisor: Associate Professor Nawawi Chouw, n.chouw@auckland.ac.nz

Natural material-based structures in earthquakes

In the production of current conventional building materials, i.e., steel and cement, CO2 are released. Hence, these materials are not eco-friendly. In addition, steel is expensive and heavy and thus will generate large inertia forces during a strong earthquake. It is also only a matter of time before corrosions occur and lead to unpredictable maintenance costs not only due to replacement, but also costs due to down time, i.e., the time when the structures and their surrounding cannot be used. In contrast, natural materials not only attract negligible cost, but they are also environmentally friendly and contribute to the well-being of the users of the structures. The research focuses on the use of natural materials in future earthquake-resistant structures.

Main Supervisor: Associate Professor Nawawi Chouw, n.chouw@auckland.ac.nz

Using Discrete Element Analysis to develop an assessment methodology for URM building pounding during earthquakes

It is well known that unreinforced masonry (URM) buildings are prone to pounding during earthquakes. Many studies on building pounding have been undertaken, but a simple assessment methodology for URM buildings has not yet been developed. This thesis study will involve a review of existing assessment methods and available experimental data associated with pounding of URM buildings, and then numerical modelling using Discrete Element Analysis to develop a methodology suitable for implementation into section C8 of the New Zealand seismic assessment methodology. It is likely that the numerical study will be augmented with small-scale shake table testing to provide experimental data to assist with validation of numerical models.

Main Supervisor: Professor Jason Ingham, j.ingham@auckland.ac.nz

Understanding the impact of vertical excitation on the seismic response of unreinforced masonry buildings

In the Canterbury earthquake sequence the level of vertical acceleration exceeded 1g in some locations. For an unreinforced masonry building this excitation implies that at various points in time the building had lost any compression associated with normal gravity loads, which is the only mechanism keeping the building standing. So far, the issue of vertical acceleration has been ignored in seismic assessment methodologies. This study will seek to understand how seismic excitations should be accounted for. It is anticipated that the study will involve implementation of discrete element analysis and possible small-scale shake table testing.

Main Supervisor: Professor Jason Ingham, j.ingham@auckland.ac.nz

Integrating virtual reality gaming technology and detailed numerical modelling of unreinforced masonry buildings

Discrete Element Analysis is an advance numerical modelling strategy for unreinforced masonry buildings. Physics engines are used in the development of virtual reality simulations. This study will seek to explore how to integrate the 2 technologies such that accurate and meaningful simulations of entire precincts of URM buildings can be undertaken. The study will involve multiple digital technologies including the acquisition of building information using drones and LIDAR, and then simulate seismic excitation.

Main Supervisor: Professor Jason Ingham, j.ingham@auckland.ac.nz

Weather Radar Nowcasting of Rainfall in Mode and Timing Decision-Making for Active Mode Commuters

The risk of adverse weather, especially getting wet from rain, is considered to be a significant barrier to active mode commuting. The benefit in terms of the reduced risk that could be achieved through the use of weather forecasts and adjusting departure time accordingly could be high. However, this depends on the intermittency of the rainfall event in question. Specifically, if the rain is 'uniform and persistent' then there is little benefit in delaying commuting. However, if the rain is very intermittent (and at times heavy), then the benefit could be considerable.

This study will explore the potential for rain weather radar nowcasting to be combined with route planning to improve the chance of 'dry' commuting. Central to the investigation will be the identification or development of a fit-for-purpose measure of 'rainfall intermittency' to allow comparisons of benefit of rain radar integration into route planning across different urban centres that are subjected to different rainfall processes and thus different rainfall patterns.

Supervisors: Professor Kim Dirks, k.dirks@auckland.ac.nz and Dr Conrad Zorn, conrad.zorn@auckland.ac.nz

Urban Infrastructure and Impact on Air Pollution Exposure from Road Transport for Active Mode Commuters

Active mode commuters such as cyclists and pedestrians are disproportionately affected by air pollution exposure from road traffic. A range of urban design features, including physical barriers such as walls and vegetation, separated cycleways and footpaths, routes that encourage movement away from congested areas, changes to traffic light phasing at peak times, all have the potential to contribute to reduced exposure. This project will involve an investigation into aspects of urban design features with a view to quantifying, through field measurements using portable air pollution monitoring equipment, the health benefit (through reduced years of life lost) of the implementation of features of interest across the population of the city.

Supervisor: Professor Kim Dirks, k.dirks@auckland.ac.nz

Seismic assessment and design of floor diaphragms
Floor diaphragms are a critical component in buildings and essential to system-level response. Past research has identified a number of vulnerabilities in existing precast concrete diaphragms and the irregular design of many new buildings is placing increasing demands on floor diaphragms. Multiple objectives/projects are currently available:

- Seismic assessment of precast concrete diaphragms and identification of macro load paths
- Comparison between floor diaphragm design with different systems (precast, post-tensioned, composite)
- Design and seismic performance of irregular floor diaphragms. Project will primarily involve numerical modelling and development of desktop design and assessment methods.

Main supervisor: Associate Professor Rick Henry, rs.henry@auckland.ac.nz

Low-damage resilient concrete buildings
Resilient structures that can not only survive large earthquakes but also allow for rapid recovery of their occupancy and functionality are critical to improving societal outcomes. Beyond the component design, the performance of the entire structure including the interactions between structural and non-structural components must be considered to meet the required performance outcomes. A number of research topics are available, related to low-damage concrete buildings and post-tensioned walls:

- Development of new wall-to-floor connection designs
- Torsional response of post-tensioned wall buildings
- Design guidelines for post-tensioned wall buildings
- Evaluation of low-damage seismic design guidelines

Main supervisor: Associate Professor Rick Henry, rs.henry@auckland.ac.nz

Tsunami generation by column collapse and pyroclastic density currents
Although usually associated with earthquakes, tsunamis can also be generated by volcanic eruptions through several different mechanisms. These include flank collapse, underwater explosions, column collapse, the entry of pyroclastic density currents into the water, and atmospheric disturbances generated by particularly large eruptions. Although recent research has provided some insight into these mechanisms, there is still a lack of information about the implications of these different generation mechanisms on the overall volcanic tsunami hazard at different locations.

This project will undertake numerical modelling and complementary physical experiments to investigate tsunami generation by column collapse and pyroclastic density currents. Numerical simulations will provide insights into the combination of parameters most conducive to large wave generation under idealised conditions, validated by small-scale physical experiments. The numerical simulations will then be extended to more realistic three-dimensional geometries representative of field scenarios, towards a detailed methodology that can be used for hazard assessment.

Main Supervisor: Professor Bruce Melville, b.melville@auckland.ac.nz
Co-Supervisor: Dr Colin Whittaker, c.whittaker@auckland.ac.nz

Use of Waste Polymer Fiber for Geotechnical Applications

Urban development and population growth imposes a huge demand on land use. The required infrastructures for this rapid urbanization leads to developments of buildings, roads, railways, sewage systems, etc. on not only firm soil but also on week and soft soils. The industry thus needs to use ground improvement methods to enhance soil characteristics for prevention of possible catastrophic failures.

The use of flat geosynthetics is a modern soil reinforcement method widely used in various geotechnical applications to enhance the strength of the soil. However, the improved strength is only in one direction and a plane of reduced shear strength is formed at its contact with the soil. The alternative to geosynthetics reinforcement is the use of fibers mixed with soil which may overcome the limitations of geosynthetics.

The purpose of this study is to use waste polymer fibers as soil reinforcement materials and investigate its effects on the soil properties. The possible geotechnical applications of this composite soil are endless such as stabilization of soils beneath the footings and rafts, embankment constructions, pavement subgrades, liquefaction mitigations, geo-environmental barriers etc. In addition, it will promote the use of waste materials which otherwise end up in landfills or incinerators.

Supervisor: Dr Arezoo Rahimi**,** arezoo.rahimi@auckland.ac.nz

Mobility-as-a-service transport system with connected and autonomous vehicles.

Mobility as a service (MaaS) is a new concept of shifting transportation solutions to an on-demand service. Instead of owning and operating individual vehicles, or taking fixed public transport services, MaaS providers offer mobility services when and where travellers need them, similarly that Netflix and Spotify offer on-demand access to movies and music. Rideshare services such as Uber are the current example of MaaS.

The availability of connected and autonomous vehicles (CAV) brings a tremendous opportunity for a CAV-enabled MaaS to continuously and automatically serve individuals' mobility using driverless cars. Without a human driver, CAVs have the potential to archive maximum vehicle occupancy and efficiency.

However, there are still various research challenges for a MaaS using CAVs to be feasible in practice. For instance, poor optimization of vehicle locations and routing may lead to an inefficient MaaS service where vehicles are not strategically located to serve users when and where they need mobility. This project will explore simulation, optimization and AI methods to provide insights into a shared (multiple riders) MaaS that is safe, effective and competitive compared to private vehicles.

Main Supervisor: Dr Minh Kieu, minh.kieu@auckand.ac.nz

Development of computer-vision-based methods for data collection in transportation

Classical data collection methods in transportation are often costly and inefficient. For instance, the use of human surveyors is very expensive, road tubes are unreliable for high-density traffic, and even loop detectors, the most popular system, have a high cost for maintenance and upkeep. In this project, we plan to explore the use of AI-based computer vision methods to identify vehicles from the traffic surveillance system from Waka Kotahi NZ Transport Agency, estimate the vehicles' actual position in a real-world coordinate system, and finally estimate the relevant transport variables, such as travel speed, traffic flow and density.

The current state-of-the-art is limited to only vehicle detection from traffic videos/images. We will extend the boundary of knowledge by developing methods to locate these vehicles on a real-world coordinate system, and from that, will be able to estimate the real speed, flow and density of the traffic system in real-time.

Main Supervisor: Dr Minh Kieu, minh.kieu@auckand.ac.nz

Department of Mechanical and Mechatronics Engineering

AI Smart Tactile Sensor

The aim is to develop a "bionic skin" using our recent work. This sensor system consists of a soft and flexible electronic skin as a sensor with artificial intelligence/machine learning that interfaces with smart devices. With the hand/fingers/feet/any object, touching the skin and then gesturing, it can recognize the gestures and can be used as input to a smart device. This project will introduce a novel tactile reality technology that can expand the augmented reality/virtual reality that can be exploited and adapted for many applications such as interactive education, enhancing the gaming experience, sports enhancement, health monitoring, rehabilitation, etc. The applicant is expected to have some working knowledge of electronics, computing, and machine learning.

Main Supervisor: Associate Professor Kean C. Aw, k.aw@auckland.ac.nz

Triboelectric Energy Harvesting

Energy harvesting is gaining popularity, especially with the increase in the use of wearables and IoTs. The ability to reduce the dependency on batteries extends the practical applications of remote sensors and wearables. This project is aimed at exploring various triboelectric materials and deploying them into unique structures where the mechanical energy can be gainfully harvested. The applicant has the freedom to explore the harvesting of mechanical energy from various sources such as human motion, etc.

Main Supervisor: Associate Professor Kean C. Aw, k.aw@auckland.ac.nz

Turbulent Natural Convection in the presence of Stratification

The structure of turbulent natural convection boundary layers is still not fully understood, particularly in thermally stratified environments. In this project, the turbulent natural convection boundary layer in a stratified environment will be modelled using DNS, with the stability of the laminar flow, the breakdown to turbulence, and the properties of the turbulent boundary layer being examined.

The results of this study will be used to calibrate the effects of stratification in both RANS and LES turbulence models.
This project will involve the use of numerical codes on high performance computers, and the development of these codes.

Main Supervisor: Dr Stuart Norris, s.norris@auckland.ac.nz

Yacht Sail Design using Adjoint Methods
Yacht sails are largely designed by experience, with no intelligent tools being used to determine the optimal sail geometry. In this project, adjoint design methods will be adopted from the aerodynamic design community and will be applied to designing sail geometries for upwind sailing. The methodology will be adapted to account for the limitations imposed on sail geometries by their aeroelastic nature. This project will involve the modification of numerical codes written in Fortran and C.

Main Supervisor: Dr Stuart Norris, s.norris@auckland.ac.nz

Turbulent flows over rough and porous media
Turbulent flows passing over rough surfaces and porous media are ubiquitous in engineering and geophysical applications. Examples include the wind blowing over a forest canopy, a river flowing over a gravel bed or water flowing around a ship's hull covered in barnacles. The surface roughness and permeability have wide implications on weather and climate in geophysics or drag (and therefore energy/fuel expenditure) in engineering, yet remain poorly understood. This project will use a novel, efficient high-fidelity direct numerical simulation (DNS) technique, a form of Computational Fluid Dynamics (CFD) to study these flows. The goal is to increase our physical understanding of the turbulence. This will pave the way toward more accurate models that predict quantities of interest such as drag or skin friction.

Main Supervisor: Dr Michael MacDonald, michael.macdonald@auckland.ac.nz

Investigating the intricacies of the internal boundary layer
The turbulent atmospheric boundary layer, the lowermost few kilometres of the atmosphere, is fundamentally dependent on the underlying ground conditions. However, abrupt changes in ground conditions generate complex Internal Boundary Layers (IBLs) as the atmospheric flow adjusts to the new surface. These changes can be localised releases of pollution from cars or chimneys, or changes in ground roughness such as at forest or city edges. Predicting the height and growth of the IBL is critical for estimating building wind loads, meteorological conditions, and climate change effects. However, a reliance on scarce empirical observations and untested modelling assumptions limits accuracy. This project will study IBLs using advanced high-fidelity computational fluid dynamics (CFD) simulations. This will increase our understanding of the essential physical makeup of the IBL, enabling more accurate turbulence, weather, and climate models to be developed.

Main Supervisor: Dr Michael MacDonald, michael.macdonald@auckland.ac.nz

Nonlinear metamaterial for broadband vibration suppression

Artificially structured materials have received significant interest in recent years, primarily because of their broad range of applications. These "metamaterials" in particular, have been successfully exploited for vibration control. However, existing metamaterials can only suppress vibrations in a narrow frequency range and may act to amplify vibrations at other frequencies. Therefore these are not suitable when the frequency of the vibrations is broadband or unknown. Conventional metamaterials are linear structures involving multiple (periodically) attached absorbers and thus featuring frequency bandgaps. The bandgaps are frequency ranges in which vibration attenuates in the structure. The research idea of the project is to study the potential of improving the vibration attenuation performance of metamaterials by introducing and exploiting nonlinearities and damping of the absorbers. The project aims to theoretically and experimentally analyse and optimize the performance of nonlinear metamaterials, i.e. structures with multiple attached nonlinear damped absorbers. The nonlinear metamaterials will be able to provide broadband vibration suppression as is relevant, e.g. for aerospace engineering and building acoustics.

What we are looking for in a successful applicant: background in theoretical and experimental analysis of dynamics and vibrations.

Main Supervisor: Dr Vladislav Sorokin, v.sorokin@auckland.ac.nz

Tidal energy for powering marine aquaculture farms

Marine farming of aquaculture is one of the fastest growing industries in New Zealand and requires a resilient supply of clean and cheap electrical energy. Tidal energy conversion has great potential for supplying New Zealand's current and future energy needs, including the marine farming industry, and provides an opportunity to grow New Zealand's economy. Previously, there have been attempts to use solar energy for aquafarming needs, however, the cost-effectiveness has been inconsistent and solar panels required frequent maintaining and replacing. Tidal energy is a more continual source of energy and has much higher energy density compared to solar. The aim of the project is to develop a novel tidal energy converter that will generate electricity at commercially required power levels with high probability and reliability. The converter should be compatible with conventional floating structures used in marine farming and be easy to manufacture, deploy and maintain.

What we are looking for in a successful applicant: theoretical background in dynamics and fluid-structure interaction; experience in Matlab and/or ANSYS

Main Supervisor: Dr Vladislav Sorokin, v.sorokin@auckland.ac.nz

Asset Monitoring in IoT framework

This project will develop a multi-layered system to monitor health conditions of machinery networked together in the Internet of Things (IoT) framework. The health conditions of the machines will be monitored by collecting vibration, speed, and electrical signals. The signals will the processed using edge devices to reduce the data dimensionality. They will be transferred to the local server connected to cloud, which will store information in database, carry out cloud computing for remaining useful life prediction and all for web-connectivity to retrieve meaning information remotely.

Main supervisor: Dr. Jaspreet Singh Dhupia, j.dhupia@auckland.ac.nz

Mixed Approach of Optimal and Machine Learning based Fault-Tolerant Control
An infrastructure for autonomous and connected systems can be created by making vehicles interact with each other and adjusting their routes according to the traffic flow. Therefore, in this project, we aim to focus towards an optimized controller design for autonomous vehicles in traffic flow which is operational in the presence of communication faults. we need to develop an optimal approach such as Artificial Neural Network or Fuzzy-Logic-based control system on a simulated traffic environment. This controller will be working under standard conditions in an urban environment. Then, a fault tolerant control strategy based on Bayesian Learning approach will be proposed which can be used to determine optimal, dynamic state limits for the traffic systems in the presence of both autonomous and conventional vehicles. In order to handle modeling uncertainty, we will use model learning to handle modeling uncertainty for complex dynamics of autonomous vehicles which are difficult to model. A simulation environment will be to evaluate the performance of the proposed controllers, so that experimental and simulation evaluation are performed.

Main Supervisor: Dr. Jaspreet Singh Dhupia, j.dhupia@auckland.ac.nz

Digital twin for predictive maintenance
The digital twin development is based on building a high-fidelity virtual entity of physical devices. However, the computation costs of carrying out simulations to predict the health status of machine require enormous data and computation resources. Therefore, the application of digital twins is often limited to simple models and simulations that do not require enormous computation efforts. In this project, we will explore how digital twins can be built to assist in the area of predictive maintenance by pre-processing measurements to reduce data size and use this information to predictive maintenance modelling in digital twins.

Main Supervisor: Dr. Jaspreet Singh Dhupia, j.dhupia@auckland.ac.nz

Speech enhancement for vulnerable listeners
Speech enhancement is an area that has been actively studied for many decades. Although various speech enhancement algorithms have been invented, only a little attention has been paid to the ability of the listeners of the enhanced speech; namely most state-of-the-art techniques target listeners with normal hearing who are the native speaker of the language spoken. This project will focus on developing novel speech enhancement algorithms for vulnerable listeners who are disadvantaged by their hearing ability and/or the proficiency of the language spoken.

Successful candidate should have a background in digital signal processing and programming skills using e.g. C, Matlab, Python. Any interests and experiences in linguistics, speech processing, audiology, and psychology would be an advantage.

Main Supervisor: Associate Professor Yusuke Hioka, y.hioka@auckland.ac.nz

High quality audio recording using unmanned aerial vehicle

Unmanned aerial vehicles (UAVs) have recently gained huge popularity across a wide range of applications, including filming, search and rescue and surveillance. Such applications take advantage of capturing visual information (i.e. video and imagery) that are otherwise impossible without making use of UAVs. On the other hand, audio signals are also one that should not be overlooked. It is common to encounter environments that are often remote and harsh, which can easily render visual information unusable. This is not the case with audio. However, audio recording using UAVs have shown to be challenging due to the high noise levels radiated from the UAV rotors. This significantly affects the quality of the audio signals to aid with any application. The problem was approached by the Acoustics Research Centre (ARC), UoA, for which a UAV system, equipped with an array of microphones and a signal processing algorithm, was developed to effectively record desired audio in-flight while removing the UAV rotor noise. Recently, a method based on machine learning was used to explore possibilities of predicting UAV rotor noise with a hybrid of microphone and non-acoustical information. However, a common problem with such data-driven system is the lack of transparency between the inputs and the result it produces. To this end, studies have been made to unravel these ambiguities with the help of analytical modelling. This project will focus on incorporating these analytical findings to optimise the current signal processing algorithm.

Successful candidate should have a background in digital signal processing and programming skills using e.g. C, Matlab, Python. Having background in mechatronics/aeroacoustics/embedded systems would be a plus but not mandatory.

Main Supervisor: Associate Professor Yusuke Hioka, y.hioka@auckland.ac.nz

Blind estimation of room acoustics parameters using microphone arrays

Key parameters in room/building acoustics such as reverberation time (e.g. T60) and direct-to-reverberation ratio (a.k.a. Clarity C50) are often used to quantify the acoustical characteristics of indoor environment. The parameters are used in various fields in acoustic from consulting of building acoustics to some audio applications such as speech enhancement. However special equipment has been required to measure those parameters. Recently blind estimation of the parameters have been actively studied, which estimates the parameters from an audio recording with general microphones without using any special equipment which would enable users to measure the parameters using their own smartphones, laptop computers, etc. This project will focus on developing a novel signal processing algorithm that will accurately estimate the parameters using microphone arrays. The project will also look into developing some potential audio applications that exploit the estimated parameters. Successful candidate should have a background in digital signal processing and programming skills using e.g. C, Matlab, Python. Having background in building/room acoustics would be an advantage.

Main Supervisor: Associate Professor Yusuke Hioka, y.hioka@auckland.ac.nz

Cislunar space situational awareness
There is a renewed interest in missions in cislunar space; the American Artemis programme and the Chinese Chang'e project are two examples. As a result, the space around the Moon will be populated with spacecraft, some of which will be manned. To guarantee the safety of these missions, it will be necessary to extend space domain awareness to cislunar space. This new need will bring many challenges. The difficulty to track these far space objects and the non-Keplerian, possibly chaotic, dynamics are two relevant ones. This research project aims to develop new initial orbit determination algorithms tailored for non-Keplerian dynamics and the use of both ground- and space-based optical observations, an essential capability for space safety in cislunar space.

Main Supervisor: Professor Roberto Armellin, roberto.armellin@auckland.ac.nz

Autonomous guidance with reinforcement learning
Spacecraft autonomy is the next challenge to reduce space mission costs and enable more intense use of space. We propose a project to develop spacecraft with self-driving capabilities in complex Earth-based and deep-space missions. We aim to develop Reinforcement Learning (RL)-enhanced Lyapunov-based guidance laws where RL is used to improve optimality while retaining stability. Devising Lyapunov control laws is an art; there is no automatic way to establish a Lyapunov function that guarantees stability while ensuring optimality. Recently, significant advances have been made in discovering the governing equations for dynamical systems from data using machine learning. Building on these results, we will investigate ways to determine the formal expression of a Lyapunov function that produces a control history as close as possible to optimal control theory-based ones.

Main Supervisor: Professor Roberto Armellin, roberto.armellin@auckland.ac.nz

Dynamics study about small-body missions
Design and operate missions to small bodies are challenging tasks due to the limited Δv budget, highly perturbed and uncertain dynamics, and constraints coming from orbit determination and contact with the ground. A primary objective for these missions is to design operational orbits that meet mission requirements, require low Δv for their maintenance and transfers, and are robust to uncertain parameters and unmodeled dynamics. Within this context, mathematical tools for a better understanding of the behaviour of the dynamics can prove useful to support the mission design process. In this research we aim to define new nonlinearity indicators, that can assist the selection of operative orbits for missions to small bodies. We will exploit the automatic computation of Taylor expansions enabled by differential algebra to extend classical first-order approaches to high-order.

Main Supervisor: Professor Roberto Armellin, roberto.armellin@auckland.ac.nz

High-Order Continuation
The solution of astrodynamics problems often requires numerical continuation procedures. The computation of families of periodic orbits or the solution of optimal control problems are two relevant examples. Standard approaches based on Newton’s

method typically provide discrete representations of the solutions with the risk of missing some important features. In this research, we aim to develop novel continuation procedures based on the differential algebra of Taylor polynomials. Our algorithms aim at generating dense family branches as an atlas of polynomial charts that are locally valid for a range of system and continuation parameters. We aim to apply the tool to problems in dynamical systems (e.g. automatic computation of solution families and bifurcations in n-body dynamics) and the optimization of multi-impulsive transfers in dynamics of increasing fidelity.

Main Supervisor: Professor Roberto Armellin, roberto.armellin@auckland.ac.nz

Robust space trajectory optimization

Planning ambitious missions with complex manoeuvres such as swing-by's, gravitational assists, or close flybys is a lengthy process. These trajectory phases are highly non-linear and critical, making their robustness challenging to assess. For instance, one needs to consider navigation, state or measurement uncertainties, and verify that celestial body approaches are compatible with planetary protection.

While current methods consist in performing deterministic trajectory design and navigation analyses sequentially, there is increasing interest in tools that allow the merging of these two phases. Such techniques would avoid iterating between mission analysis and navigation, thus saving time and resources and, more importantly, providing optimal and robust trajectories. High-order methods are of great interest to handle non-linear growth of uncertainties, with, for instance, the approximation of the dynamics through high-order Taylor expansions around a reference trajectory. Could this polynomial approach show better results than linear techniques and improve optimality?

Main Supervisor: Professor Roberto Armellin, roberto.armellin@auckland.ac.nz

Engineering Science

Computational Fluid Dynamics for river bioremediation

Improving river water quality is a major priority in New Zealand, with the main source of contaminants being nitrates and e-Coli from farming. While there has been much work conducted to-date on designing bioremediation technologies in slow moving bodies of water, such as lakes and ponds, their application in faster moving environments such as rivers is much less explored. This project will build upon a preliminary study, using computational fluid dynamics to design in-river bioremediation technologies that are optimised to maximise removal of contaminants.

Main Supervisor: Associate Professor Richard Clarke, rj.clarke@auckland.ac.nz

Characterization of 3D printing manufacturing defects in cellular structures

This project is concerned with the effect of imperfections and defects during 3D printing process of cellular-type structures like lattices. A lattice is a cellular structure which has been widely used in aerospace and medical industries with great properties, such as high specific stiffness and strength, heat insulation and energy damping attenuation. 3D printed lattice structures often have significant variability in quality due to variable strut

diameters, material overlapping at the vicinity of the strut nodes and unprocessed materials. Our developed mathematical formulation can predict compressive performance of the lattices with considering material overlapping defect. For computational modelling of a final 3D printed lattice, a non-ideal model of lattice cube with considering variable strut thickness is necessary. Image processing techniques should be used to characterize the geometry of the lattice and morphology of the defects and to construct a 3D model of the defected final lattice.

The CSC-funded PhD students will be part of Centre for Advanced Composite Materials (CACM) and Engineering science. The new PhD students can leverage our cutting-edge research facilities (additive manufacturing facilities, CACM mechanical testing equipment, high-performance computers for coding and computational modelling). This project will involve coding, mathematical modelling, computational modelling in FE solver, 3D printing manufacturing and mechanical experimental tests.

Main supervisor: Dr Maedeh Amirpour (She/her), m.amirpourmolla@auckland.ac.nz

Decomposition Algorithms for Multi-Objective Optimisation.
Decomposition techniques for optimisation problems have significantly improved the ability to solve problems of ever-increasing complexity and problem size. Many real-world problems must be formulated with multiple objectives; solving multi-objective optimisation problems (MOPs) means identifying sets of Pareto efficient solutions representing available trade-offs. We will integrate problem decomposition concepts and MOP techniques to more effectively deal with complexity in MOPs. We will analyse this integration theoretically, derive solution algorithms and test them on real-world problems. Some initial algorithms for multi-objective decomposition have been developed and we will adapt these to the solution of multi-objective integer linear programming problems in this research project. This project is well suited for a student with background in mathematical optimisation / Operations Research and strong programming skills.

Main supervisor: Dr Andrea Raith, a.raith@auckland.ac.nz

Optimisation for Wireless Powered Infrastructure
The PhD student will conduct research into the placement and configuration of wireless charging systems. We will investigate the optimal placement of charging infrastructure on roadways for urban and intercity travel. Particular vehicle fleets may have different needs that will be modelled. For instance, an electric taxi service might charge while waiting for passengers, whereas a bus service could charge at stops, traffic lights or on particularly steep hills. Models for different transport systems (urban, inter-urban) will be developed and used to optimise placement of charging infrastructure to identify a best value for money solution to support electrification of the transport system. In addition, we will study the special case of high mileage commercial vehicle fleets (taxis, delivery services) that often operate in urban areas with high potential impact on air quality through electrification.

Specific areas of research focus include: (1) Investigation of the optimal placement of IPT facilities on a road network under mixed traffic conditions based on an integration of optimisation and simulation models of the Auckland motorway network.

(2) Identification of optimal wireless charging configuration for urban commercial electric fleets. We will investigate how a fleet of electric taxis or shuttles can best be supported by a combination of wireless and dynamic charging infrastructure considering location and setup (power level and frequency) of charging systems. We will also investigate how a public bus transport system can be transitioned to fully electric with support of wireless charging infrastructure. (3) Study of the electrification of urban and intercity road networks for commercial fleets with a focus on freight transport within New Zealand's North Island.

Main supervisor: Dr Andrea Raith, a.raith@auckland.ac.nz

Computational Engineering for Processing of Advanced Composites
This project is concerned with the manufacture and processing of advanced composites materials as used in the aerospace, marine, transportation, sporting and other sectors. We have developed mathematical and computational models which simulate these processes, and which we use to optimise in terms of cost and time to development. Our simulations model the structural deformation of the fibrous material reinforcement (non-linear and viscoelastic constitutive models) and resin flow (porous media fluid flow).

Many processes are made more efficient by applying heat to the manufacturing moulds, to lower fluid viscosity and speed up reinforcement wetting-out. The goal of this project is to extend our modelling work to include thermal effects, by integrating energy equations with the structural and fluid-flow models, which will allow for process optimisation with respect to applied temperature profiles. We also want to use our experimental data to carry out inverse modelling and parameter estimation using statistical analytics methods.

Main Supervisor: Associate Professor Piaras Kelly, pa.kelly@auckland.ac.nz

Chemical and Materials Engineering

Battery and hydrogen technologies toward low-carbon emissions economy
Battery and hydrogen are vital in decarbonising many industrial sectors, primarily energy, transport and industrial processing. Various projects are available in the area of hydrogen and battery technologies, including hydrogen storage materials, on-demand hydrogen productions, electrolytes and anode materials, as well as new battery designs for niche applications. The aims of these projects are to develop materials that have excellent performance and are sustainable and environmentally friendly. The candidates should have a Master of Science or Master of Engineering degree; they are expected to have excellent communication skills and are self-motivated. Prior experience in materials synthesis, process design and electrochemistry are highly desired. The candidates will be exposed to a dynamic research forefront with strong support from a well-established research group.

Contact: Professor Peng Cao, p.cao@auckland.ac.nz

Innovative storage of chilled meat and fish at sub-freezing temperatures
We will develop innovative freezing techniques to maintain the quality of chilled meat at sub-freezing temperatures. The challenge that we are trying to address is the short shelf life of chilled meat and fish, which are highly valued due to its premium quality. The big question that we are aiming to address in this project is: can we extend the shelf life of chilled meat? This will involve innovative methods to 'freeze' the chilled meat and fish so that its quality is preserved. This project sits at the crossroad of engineering, food science and food safety.

Contact: Associate Professor Meng Wai Woo, wai.woo@auckland.ac.nz

Atmospheric freeze drying of food and pharmaceutics
Vacuum Freeze Drying is the industry workhorse to produce freeze dried food. It is a very slow and expensive batch process. We will explore a potential alternative which is the Atmospheric Freeze Drying (AFD) process. The big challenge that we are trying to address is: how do we intensify the AFD process so that it is scalable? This project requires a student with strong interest in heat and mass transfer as well as computational fluid dynamics. Experience in food and pharmaceutical system are not required but will be an advantage.

Contact: Associate Professor Meng Wai Woo, wai.woo@auckland.ac.nz

Electrode surface dynamics in water electrolysis for green hydrogen production (Marsden FS funded project)
Water electrolysis is the leading process for "green" hydrogen production using electricity generated from renewable sources. This hydrogen can then be applied as a form of green energy to replace fossil fuels. However, poor energy efficiency and degradation of water electrolysers over their operating lives remain major drawbacks for electrolytic hydrogen production. In this research, you will address a key challenge in efficient water electrolysis in a Proton Exchange Membrane (PEM) water electrolyser under intermittent power supply conditions. The electrode/catalyst surface dynamics will be investigated through experimental and mathematical modelling. This research will crucially inform strategies extending the lifespan of electrolyser components and their capability for continuous operation. The medium-term objective is to improve the efficiency and cost-effectiveness of electrolytic hydrogen production.

Contact: Dr Jingjing Liu, jingjing.liu@auckland.ac.nz

Addressing energy and environmental challenges with membrane technology
Membrane-based separation technology is gaining popularity since it is considered clean technology, energy-efficient, has a small footprint, and can produce superior product quality. Various projects are available in membrane filtration technology for water and wastewater treatment, desalination, resource recovery, and food processing applications. The projects include the development of composite membranes with 2D materials, novel membrane fouling mitigation strategies, and a hybrid membrane system (membrane-based separation system integrated with a bioreactor, 3D printing, or other technologies).

Contact: Dr Filicia Wicaksana, f.wicaksana@auckland.ac.nz

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AUCKLAND LAW SCHOOL

Tax Law

Professor Craig Elliffe specialises in taxation law. Craig was appointed to a chair after 14 years as a tax partner at KPMG and nine years as a tax partner at Chapman Tripp. Craig's research areas are in the field of international tax, corporate tax and tax avoidance. He is the author of *International and Cross-Border Taxation in New Zealand* (Thomson Reuters), which was awarded the JF Northey best law book award in 2015, and *Dividend Imputation: Practice and Procedure* (Lexis). His latest book, *Taxation of the Digital Economy: Theory, Policy and Practice*, was published by Cambridge University Press in 2021. He was a member of the Permanent Scientific Committee of the International Fiscal Association (2011-2018) and a member of the New Zealand Government's Tax Working Group (2018/19). Craig is an experienced PhD supervisor, who has supervised local and overseas candidates

Contact: Professor Craig Elliffe, c.elliffe@auckland.ac.nz

International Law

Dr Treasa Dunworth is an Associate Professor at the University of Auckland Faculty of Law. She holds a PhD from Melbourne University, and an LLM from Harvard University. Her research interests are in international law and particularly international law of disarmament.

Contact: Associate Professor Treasa Dunworth, t.dunworth@auckland.ac.nz

Dr An Hertogen is a senior lecturer at the University of Auckland Faculty of Law, where she completed her PhD in 2012. She also holds an undergraduate law degree from the KU Leuven in Belgium, and an LLM from Columbia University. Her research interests are in international law and international economic law. She is particularly interested in questions on the allocation of domestic jurisdiction in relation to the regulation of economic issues.

Contact: Dr An Hertogen, an.hertogen@auckland.ac.nz

Private law

Professor Warren Swain is one of the world's leading historians of private law. He is currently Deputy Dean. He was educated at Hertford College, the University of Oxford, where he was awarded a BA, MA, BCL and D.Phil. He has previously taught at Oxford, Birmingham and Durham universities in the UK and the University of Queensland in Australia. He was elected a life member of Clare Hall, University of Cambridge and is a Fellow of the Royal Historical Society. He is secretary for the Selden Society in New Zealand. Professor Swain is interested in the history of contract, tort and unjust enrichment as well as intellectual history more broadly especially in so far as it applies to the law. He also undertakes research in comparative legal history, the history of English law in a colonial context and Roman law.

Contact: Professor Warren Swain, w.swain@auckland.ac.nz

Dr Arie Rosen specialises in legal philosophy and contract law theory. He is a founding co-director of the New Zealand Centre for Legal and Political Theory and the Secretary of the Australasian Society of Legal Philosophy. His works appears in leading publications in law, including the Oxford Journal of Legal Studies, the University of Toronto Law Journal, the Oxford Studies in Private Law Theory, and Law and Philosophy.
Arie is open to supervision of PhD students on various topics in legal philosophy and theory private law (property, contract, torts). He is particularly interested in projects examining the relationship between political theory, political institutions, and private law.

Contact: Dr Arie Rosen, a.rosen@auckland.ac.nz

Indigenous People and Criminal Law

Dr Fleur Te Aho is a senior lecturer in the University of Auckland's Faculty of Law where she researches and teaches on Indigenous peoples and the law, and criminal law. Fleur has an especial interest in understanding how international law norms regarding Indigenous peoples influence domestic law, Indigenous peoples' rights, and Māori and criminal justice.

Contact: Dr Fleur Te Aho, f.teaho@auckland.ac.nz

Healthcare Law

Professor Jaime King is an expert in healthcare reform, specializing in some of the most complex challenges facing domestic healthcare systems, especially within the United States. Her current research focuses on reform efforts using a combination of regulatory and competition-based tools to reduce costs and promote equitable access to healthcare. Her past scholarship has also addressed questions related to the balance of individual autonomy and state power, including but not limited to medical decision making and constitutional and regulatory questions regarding genetic testing.

Contact: Professor Jaime King, jaime.king@auckland.ac.nz

Family Law

Professor Mark Henaghan is the Co Director of the PhD program at the Auckland University Law Faculty. Professor Henaghan is a Fellow of the Royal Society of New Zealand for the excellence of his research in the humanities. He is a Fellow of the International Academy of Family Lawyers which connects the leading Family Lawyers from around the world.

Professor Henaghan specialises in all aspects of Family Law including children's rights, parents, grandparents and wider family rights and duties, divorce, family violence, financial and property family disputes, adoption and surrogacy, child abuse, international child abduction, international adoption. Professor Henaghan also has research interests in the legal and ethical implications of the discovery of the Human Genome as well as how Judges should play their roles as decision-makers. Professor Henaghan is an experienced PhD supervisor who has supervised a number of PhDs from around the world.

Contact: Professor Mark Henaghan, mark.henaghan@auckland.ac.nz

UNIVERSITY OF AUCKLAND
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NEW ZEALAND

MEDICAL AND HEALTH SCIENCES

3D Hydrogel Scaffolds to Support Cell Replacement Therapy for Spinal Cord Injury

The project:
Spinal cord injury (SCI) has a profound impact on quality of life as sufferers contend with loss of function, paralysis and pain. Currently there is a lack of options available to treat SCI. We are investigating if cell replacement therapy can help reconnect nerve pathways damaged following a SCI.

This project aims to develop hydrogel scaffolds to support the transplant of human oligodendrocytes, differentiated from human fibroblasts, into a rat model of spinal cord injury.

The properties of biocompatible and biodegradable hydrogels will be tuned to achieve materials suitable for direct surgical implantation onto the spinal cord. The materials will need to support oligodendrocytes growth and differentiation. Cell-laden scaffolds will be prepared by 3D bioprinting. The scaffolds will be mechanically robust, yet soft, and have desirable degradation rates to ensure integration into the host tissue.

The supervisor:
Dr Darren Svirskis (d.svirskis@auckland.ac.nz) is an Associate Professor and Director of Research in the School of Pharmacy. He has expertise in the use of biomaterials to communicate with and influence the body chemically through the intelligent delivery of drugs, and electrically using microelectrode arrays. He currently uses hydrogels as scaffolds for cell culture, and for the controlled delivery of drugs.

The team:
Dr Bronwen Connor (b.connor@auckland.ac.nz) is a Professor in Pharmacology and Head of the Neural Reprogramming and Repair Lab at the Centre for Brain Research, University of Auckland. Her specific interest is in the development of novel protective or regenerative strategies to treat neurological disease.

Dr Amy Chapman (a.chapman@auckland.ac.nz) is neuroscientist with expertise in reprogramming human skin cells to human brain stem cells, specifically the oligodendrocytes to be used in this project.

Dr Jenny Malmström (j.malmstrom@auckland.ac.nz) is an Associate Professor in the Department of Chemical and Materials Engineering. Her research focusses on creating functional biointerfaces to understand and control biological systems.

Dr Bruce Harland (bruce.harland@auckland.ac.nz) is a neuroscience researcher currently leading the development of a bioelectronic implant as a treatment platform and neural recording device in a rodent model of spinal cord injury.

Dr Brad Raos (b.raos@auckland.ac.nz) is a bioengineer with materials expertise whose research involves understanding cell-to-cell communication in the central nervous system.

The skills:
During this PhD the candidate will learn to prepare and characterize hydrogel materials, fabricate implants using a 3D printer and conduct cell culture experiments. There will also be the opportunity to conduct rodent experiments.

Exploring the roles of traditional Chinese medicine (TCM) practitioners and their patients in enhancing pharmacovigilance for TCMs in New Zealand

TCM has a long history of traditional use in China, and its use is embedded in healthcare, whereas in western countries, including New Zealand (NZ), TCM typically sits outside mainstream medicine. Nevertheless, the use of Traditional Chinese Medicine (TCM) for well-being and treatment of health conditions is a popular choice among New Zealanders. The New Zealand Health Survey 2006/07 reported that of the 18.2% of adults who had consulted a traditional/complementary/alternative medicine (TCAM) practitioner in the previous 12 months, 6.7% had consulted a TCM practitioner. There are estimated to be up to 1200 TCM practitioners in NZ.

In recent years, the use and safety of traditional Chinese medicines (TCMs), has attracted attention globally. Key organisations concerned with the safety of medicines (e.g. World Health Organisation, International Society of Pharmacovigilance) have emphasized the need to enhance safety monitoring and reporting systems for TCMs (as well as for other types of traditional medicines and natural health products). All medicines have safety concerns, and proper practice of TCM already incorporates approaches to reduce the toxicity of TCM preparations. However, it is accepted both within and outside China that to modernise TCM practice, pharmacovigilance for TCMs needs to evolve. In New Zealand, very few reports of adverse reactions associated with TCMs are received by the Centre for Adverse Reactions Monitoring.

In New Zealand, in 2021, it was determined that the practice of TCM poses a risk of harm to the public and, therefore, that the profession should be regulated under the Health Practitioners Competence Assurance Act 2003 to provide assurances to the public that TCM practitioners in NZ are competent to practise. As part of regulation, statutory registered health professionals usually have a code of ethics and/or practice that includes the expectation, or at least, encourages those practitioners to seek to identify and report suspected adverse reactions (including those associated with TCM treatments) experienced by their patients.

This project aims to investigate ways of enhancing safety monitoring for TCMs. The first phase will explore the experiences, views, practices and knowledge of TCM practitioners

and their patients in NZ on the safety of TCMs, and on identifying and reporting safety issues. This work will involve qualitative (e.g. interviews, focus groups) and quantitative (e.g. questionnaires/surveys) methods involving TCM patients and practitioners. The second phase involves developing an educational/ awareness intervention on TCM safety/pharmacovigilance and assessing its impact on TCM patients' and TCM practitioners' identification and reporting of safety concerns associated with TCMs. The project will involve developing collaborations and engaging with TCM organisations and practitioners in NZ, with the NZ Pharmacovigilance Centre, and with collaborators in China and elsewhere (Professor Jia-bo Wang, Dean, School of Traditional Chinese Medicine, Capital Medical University, Beijing, China; Dr Lida Teng, University of Tokyo, Japan).

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Contact: Associate Professor Jo Barnes, j.barnes@auckland.ac.nz

Centre for Co-Created Ageing Research

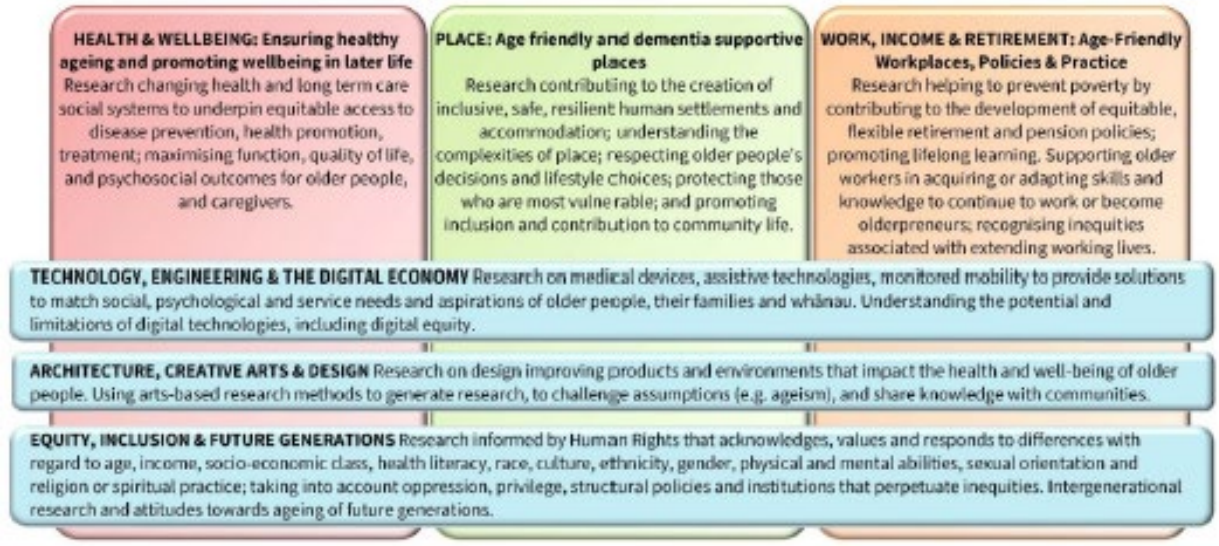
The Centre for Co-Created Ageing Research (CCREATE-AGE) is a new University Research Centre (2022) that will address research questions that are informed by communities, supported by skilled researchers to co-create an innovative and robust research that delivers practical solutions that work in practice, in the communities they were designed for. It will:

- Position equity as a core requirement for research excellence
- Establish and maintain a community of co-creators (older people, caregivers; academics; clinicians, practitioners and professionals in the public sector; business and industry) coordinated by an academic hub
- Foster cooperation with external stakeholders building partnerships, developing and prioritising new ideas for rapid translation into research, placing older people at the centre of innovation
- Provide the infrastructure to generate and support innovative co-created ageing research
- Build research capacity, developing a critical mass of transdisciplinary researchers through a pipeline of academic development, leaderships and succession planning
- Co-ordinate activities, publicising co-created ageing research and impact
- Harness the power of feedback, capturing learning from activity and feeding it back into the operation.

The opportunity:
There is an opportunity to undertake your PhD in a transdisciplinary research centre recognised as world-leading for equity-focused, co-created, ageing research that contributes to Sustainable Development Goals and delivers real-world change for, and with, older people and communities. We will provide support to PhD candidates that wish to undertake co-created ageing research spanning more than one discipline and aligned to any of the four research themes: research that will meet the self-identified needs and aspirations of older people, researchers, stakeholders and funders.

The Operational Management Team for CCREATE-AGE comprises representatives from all faculties in the University of Auckland (Medical and Health Sciences, Science, Engineering, Arts, Creative Arts and Industries, Education and Social Work, Law, Business School, Liggins Institute and Auckland Bioengineering Institute), and will facilitate the identification of transdisciplinary supervisory team.

You will join a vibrant community of co-creators bonded in a quadruple helix innovation ecosystem of mutual benefit, coordinated from an academic hub. You will be supported in a safe and innovative place to learn, and your research will have an influential impact on health, environment, society and science. At the end of your PhD candidature you will be an expert in co-created ageing research.



Contact: Professor Vanessa Burholt, vanessa.burholt@auckland.ac.nz

Improving continence management for people with dementia in the community
The number of people living with dementia (PLWD) in Aotearoa New Zealand is presently estimated at 70,000 and it is anticipated that this number will increase to 102,000 by 2030. In China, prevalence for those ages 60+ years is estimated to be 5.3% (≈ 13.2 million PLWD). There is no current cure for dementia, but there are opportunities to improve the quality of life of PLWD and their caregivers, and to delay entry into residential care. Long-term care systems for PLWD have not yet been established in China, and better support for family caregivers and guidelines for professionals providing community-based care is required.

The likelihood of experiencing continence issues increases as dementia progresses. With moderate to severe dementia, difficulties include recalling learned information (e.g. the location of a toilet, what a toilet looks like and how to use it) or decoding what

sensations mean (e.g. the need to void), a decline in judgement (e.g. time required to get to and use the toilet, or what to do with faeces or soiled clothing if a toilet could not be reached in time), and how to maintain personal hygiene and cleanliness after voiding. As dementia has an impact on the physiological functions of the body it can contribute to bladder or bowel dysfunction (e.g. neurogenic detrusor dysfunction). Overall, incontinence is rarely solely due to the pathology of dementia and is more frequently the result of cognitive impairment, or due to co-morbidity which is overlooked because the person has dementia

Caregivers rate the independent use of the toilet as the most important activity of daily living that they would like the PLWD to retain. Rates of moving into ARC are much greater for PLWD than for older people without dementia, and incontinence is consistently identified as a predictor for institutionalisation in this population. This suggests that more can be done to support caregivers and family.

Promoting continence and managing incontinence for PLWD often requires around the clock vigilance. Sleeplessness from constant watchfulness can contribute to exhaustion, potentially jeopardising caregiving in the community. Although caregivers need pragmatic advice on how to deal with challenges, (e.g. resistance to using pads, voiding in inappropriate places, handling faeces, refusing to clean after voiding) the effectiveness of environmental adaptations, behavioural techniques and containment products for PLWD in the community have yet to be assessed. We do not know how caregivers, and family of Chinese PLWD in Aotearoa or China manage the challenges associated with promoting continence and managing incontinence. Obligations to provide care based on normative expectations of family solidarity (such as filial obligations prevalent in Chinese communities) may not be referred to as 'caregiving', and this, along with the stigma associated with both dementia and incontinence may contribute to caregivers not seeking out services.

The Opportunity:
There is an opportunity for one or more PhD scholars to work with an esteemed team of scientists who have been funded by the Health Research Council of New Zealand to improve continence management for people with dementia in the community. The scholar may to seek to understand the extent of the challenge (prevalence and incidence of urinary and faecal incontinence for PLWD) and/or current practices of professionals, PLWD and caregivers, to identify promising strategies to help address this challenge in China, and/or for Chinese migrants in New Zealand.

Expertise and track record of the research team:
Principal Investigator Professor Vanessa Burholt (vanessa.burholt@auckland.ac.nz) Professor of Gerontology and Director of the Centre for Co-Created Ageing Research, has expertise in leading large multidisciplinary team (NZ$103.7 million), supervising PhD candidates, mentoring researchers and delivering impactful research for older people. She has capacity to supervise new PhD candidates. Burholt has published widely including in Nature and Nature Communications.

Dr Avinesh Pillai (a.pillai@auckland.ac.nz) is Senior Research Fellow in the Department of Statistics. Professor Ngaire Kerse (n.kerse@auckland.ac.nz) holds the Joyce Cook Chair in Ageing Well and has a clinical role as a GP. Dr Gary Cheung (g.cheung@auckland.ac.nz) is a senior lecturer in the field of old age psychiatry with expertise developing, testing and delivering behavioural interventions for PLWD. Dr Anna Lawrence is a consultant urologist and is President of Continence NZ. Dr Kathryn Peri is a Senior Lecturer with research experience with PLWD and practical experience as a former continence nurse. Dr Rosie Gibson is a Research Officer with expertise in psychology and sleep health. Dr Sharon Awatere is a Research Fellow providing

leadership for research with Māori. Dr Lisa Williams is a Research Fellow who has been involved in projects using creative outputs as a medium to support knowledge translation.

Increased risk of cardiometabolic outcomes in women diagnosed with gestational diabetes mellitus and improving management in New Zealand.

PhD Supervisors: Dr Barbara Daly, Senior Lecturer, Faculty of Medical and Health Sciences, b.daly@auckland.ac.nz and Associate Professor Dr Lynne Chepulis, Medical Research Centre, University of Waikato.

Increased risk of cardiometabolic outcomes in women diagnosed with gestational diabetes mellitus and improving management in New Zealand.
Gestational diabetes mellitus (GDM) is increasing globally, largely due to the obesity epidemic. It is well established that women diagnosed with GDM have about 20 times the risk of developing type 2 diabetes in their lifetime and more recent studies show a doubling in risk of cardiovascular (CV) events. Although glucose levels return to normal for most women following delivery, they remain at high risk for developing risk factors for cardiometabolic outcomes. Follow up screening and management of HbA1c, lipids, blood pressure, smoking status, BMI, nutritional intake and physical activity is poorly documented.
The main aims of this project are to: 1) explore two large national and primary health care data sets to collate to document current follow up management practices; 2) identify gaps in management and develop a best practice intervention and 3) influence policy and funding for appropriate follow up and management of women with risk factors for type 2 diabetes and CV disease.

Specifically, this project would involve:

- Working with large datasets to identify current practices in NZ
- Complete a systematic review and meta-analysis of follow up intervention GDM trials
- Work with stakeholders, make policy and best practice guideline recommendations to ensure appropriate follow up and management in primary care
- Potential for a post-doctorate follow-up study to evaluate policy and guidelines changes

Current relevant research by supervisors:
Dr Barbara Daly's current research project is titled 'Cardiovascular disease and type 2 diabetes in women diagnosed with gestational diabetes in New Zealand – a retrospective matched case control cohort study'. This study is utilising a national dataset with over 600,000 women who gave birth over a ten year period in NZ.

Associate Professor Lynne Chepulis has extensive experience leading healthcare projects. Currently she holds more than $2 million in funding to explore: 1) the impact of health system factors on inequity in diabetes prescribing, 2) use of hospital and linked datasets to characterise outcomes for lung and colorectal cancer, 3) use of continuous glucose monitors for T2D patient self-management, 4) exploring risk factors for diabetes development and 5) obesity management in primary care.

Contact: Dr Barbara Daly, Senior Lecturer, Faculty of Medical and Health Sciences, b.daly@auckland.ac.nz
Associate Professor Dr Lynne Chepulis, Medical Research Centre, University of Waikato.

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- Daly B, Toulis KA, Thomas N, et al. Increased risk of ischemic heart disease, hypertension, and type 2 diabetes in women with previous gestational diabetes mellitus, a target group in general practice for preventive interventions: A population-based cohort study. PLoS Med 2018;15(1):e1002488.

Topical medicated spray for wound application

Background: Delivering therapeutic agents to wound beds remains a challenge. Traditional dosage forms, such as creams and ointments not only require a repeated application but are also very difficult to apply to the wound site, affecting patient compliance. This project aims to develop a sprayable drug delivery system to achieve ease of application to the wound site, with the ability to provide a slow release of the therapeutic agents for an extended duration, thus reducing the need for repeated application. Thermoresponsive polymer, poloxamers will be investigated for developing a sprayable in situ gel system. Poloxamers are liquid at room temperature, easy to spray and gels at body temperature to form a slow-release gel depot. The unique 3D gel network, mimics the natural extracellular skin matrix, provides an optimal moist environment for healing, and supports cell proliferation.

It is hypothesised that a spray-on poloxamer-based system will gel on contact with the wound and achieve controlled delivery of therapeutic agents that alone or in combination with grafting will provide faster-wound healing.

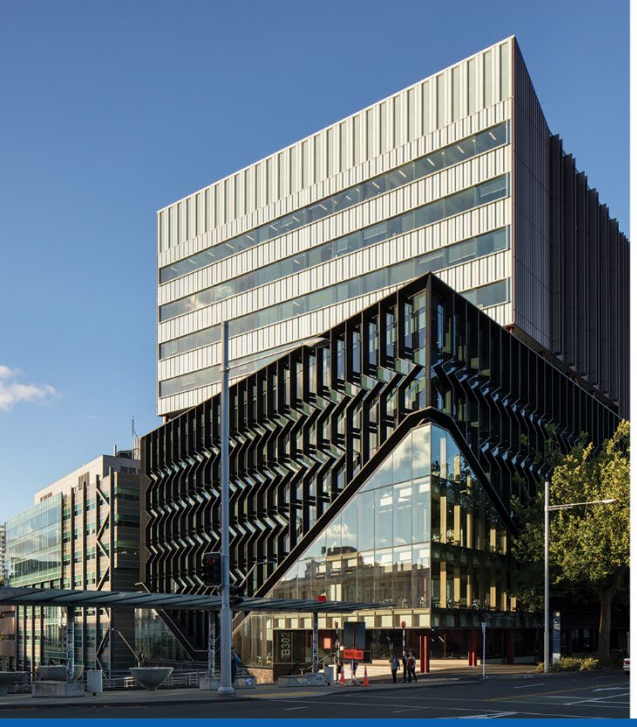
During this project, the student will develop an optimized poloxamer based sprayable in situ gel system for the controlled delivery of therapeutic agents. The developed in situ gel will be evaluated for its spray characteristics along with other gel properties and in vitro release profile. Later the developed in situ gel will be tested for its in-vivo performance either using cell culture-based models or animal models.

This research will demonstrate a new way to deliver medicines for wound care.

Skills: The student should have a pharmaceutical science background with a particular interest in controlled drug delivery.

Supervisory team:
Dr Manisha Sharma, (manisha.sharma@auckland.ac.nz), Senior Lecturer, School of Pharmacy – expert in the formulation and drug delivery science with a particular focus on injectable depots, implants and stimuli-responsive novel drug delivery systems.

Professor Anthony Philips, (a.phillips@auckland.ac.nz), School of Biological Sciences – expert in skin biology and wound healing



UNIVERSITY OF AUCKLAND
Waipapa Taumata Rau
NEW ZEALAND

SCIENCE

Subjects in the Faculty of Science

The projects listed in this booklet are just a few of the many possible research projects suitable for doctoral study in the Faculty of Science at the University of Auckland. For information about other areas of active research in which it might be possible to undertake doctoral studies, see the following webpages:

- Doctoral study in Biological Sciences
- Doctoral study in Chemistry
- Doctoral study in Computer Science
- Doctoral study in Environmental Science
- Doctoral study in Exercise Sciences
- Doctoral study in Food Science
- Doctoral study in Forensic Science
- Doctoral study in Geography
- Doctoral study in Geology
- Doctoral study in Marine Science
- Doctoral study in Mathematics
- Doctoral study in Mathematics Education
- Doctoral study in Physics
- Doctoral study in Psychology
- Doctoral study in Speech Science
- Doctoral study in Statistics

School of Chemical Sciences

Analysis of plant-based "milks"
Alternative products to mammalian milks are currently on the rise in popularity and consumption. Furthermore, there is the belief that plant-based "milks" could offer a more sustainable source of nutrition in the future. This project will be based upon the investigation of a range of plant-based "milks" to analyse their chemical composition using a range of analytical methods, particularly FTIR, NMR and HPLC. This analysis and the research in this project will ultimately provide valuable information and insight into the chemistry behind this ever-increasing consumable sector.

Supervisor: Dr Lisa Pilkington, lisa.pilkington@auckland.ac.nz

Development of QSAR-Software for Drug Development and Design
One of the most important goals in drug development is to establish a quantitative structure-activity relationship (QSAR) between the structure of a compound and its biological activity. Current strategies to generate QSARs are often simple and fail to adequately account for the complex interaction between structural features. This project aims to create an R-based lead-optimisation QSAR-development statistical software package that will be the definitive tool for medicinal chemistry lead-optimisation projects, thereby having far-reaching usage and applicability. This package will involve the use of a range of machine learning techniques to best model the QSAR of a class of bioactive compounds in order to direct future analogues in the process of drug development and class optimisation.

Supervisor: Dr Lisa Pilkington, lisa.pilkington@auckland.ac.nz

Synthesis of biologically active lignan natural products
Lignans are a class of compound which has become the target of particular interest to researchers, owing to their numerous biological activities including anti-cancer and cytotoxic properties and have also shown an array of pharmacological activities, including antifungal, antibacterial, antioxidant and anti-proliferative properties. In this project we will explore our recently developed methods to prepare a range of classes of lignan natural products using a common, easily made intermediate. This compound can be converted to both THF lignans and also aryl-tetralin lignans, both classes have highly bioactive members including clinically used drugs. The student undertaking this project will be involved in organic synthesis, purification and compound characterisation (NMR, MS, IR, etc). They should have a reasonable knowledge of synthetic chemistry.

Supervisor: Professor David Barker, d.barker@auckland.ac.nz

Analysis of vaping liquids to understand the composition of product available
Vaping is becoming increasingly up taken, particularly in younger members of society. This project will be based upon the investigation of a range of vaping liquids to analyse their chemical composition using a range of tools, particularly HPLC. This analysis and research in this project will ultimately provide valuable information and insight into the chemistry behind this ever-increasing consumable sector.

Supervisor: Dr Lisa Pilkington, lisa.pilkington@auckland.ac.nz

Synthesis of Novel inhibitors of Phospholipase C, an enzyme involved in cancer cell proliferation
Phospholipase C is a promising biological target for anticancer drug therapy with compounds binding to PLC showing marked growth inhibition of haematological tumour cells. We have recently discovered a class of compounds which are potent inhibitors of cell growth. Morphology and motility assays using triple negative breast cancer cell lines lead to the conclusion that PLC is the most probable bio-molecular target of these compounds however other important targets may be affected. The student working in this project will be involved in the design (computation modelling), synthesis and biological testing of novel compounds to treat cancer. Students with an interest in organic or medicinal chemistry are encouraged to apply.

Supervisor: Professor David Barker, d.barker@auckland.ac.nz

Synthesis of novel bio-based materials for water purification
One of the world's biggest challenges is pollution of fresh waterways. Two of the main pollutants that are plaguing our freshwater is nitrates and heavy metals, high levels of which have been shown to cause significant health and environmental problems. The primary aim of this project is to develop new filter materials using all natural, bio-based, compounds that will be able to purify water through the removal of damaging pollutants. This new technology will combine knowledge from areas of synthetic chemistry, polymeric materials and membrane science to produce a material capable of reducing toxins from fresh water.

Supervisor: Professor David Barker, d.barker@auckland.ac.nz

Synthesis of DNA binding trioxatriangulenium analogues
Trioxatriangulenium (TOTA) ions are highly stabilised planar carbocations that have excellent DNA intercalating properties. Interestingly these molecules can change shape from the bioactive flat form to an inactive umbrella form in a reversible manner meaning that they can become activated within cancer cells alone. We have recently discovered these compounds inhibit the growth of numerous cancers at nanomolar dosages but are limited in their activity by their overall solubility. In this project, we will prepare novel TOTA analogues that have solubilising groups and are conjugated to other DNA binding anticancer agents. The aim is to prepare soluble derivatives with increased bioactivity. The student working in this project will be involved in the design (computation modelling), synthesis and biological testing of novel compounds to treat cancer.

Supervisor: Professor David Barker, d.barker@auckland.ac.nz

Highly flexible, stretchable and adhesive conducting polymers electrode arrays for bioelectrical measurements of the stomach and intestine

Bioelectrical slow wave activity is a fundamental physiological event in maintaining the normal motility of the stomach and intestine. Slow wave abnormalities are associated with several major digestive disorders. High-resolution electrical mapping arrays have been used to investigate pathological slow wave abnormalities. However, conventional electrode materials are of high mechanical modulus, which leads to non-compliance and mechanical mismatch with the soft and deformable gut tissues. In this cross-disciplinary project, we will develop highly flexible, stretchable, adhesive, and transparent conducting polymer (CP) based electrode arrays. To achieve this, both advanced microfabrication techniques and the functionalisation of the materials will be investigated. The in-vivo electrophysiological recording performance of such electrodes will be validated using pig and rat models. Multifunctionality, including strain, temperature and pH sensing will be incorporated into the device and we can potentially employ these electrodes for applying electrical stimulation and extend to other organs, such as the heart or uterus.

Supervisors:
Professor Jadranka Travas-Sejdic, j.travas-sedjci@auckland.ac.nz
Dr Peikai Zhang, peikai.zhang@auckland.ac.nz
Associate Professor Peng Du, peng.du@auckland.ac.nz (Auckland Bioengineering Institute)

Organic electrochemical transistor (OECT)-based sensor for detection of pathogens

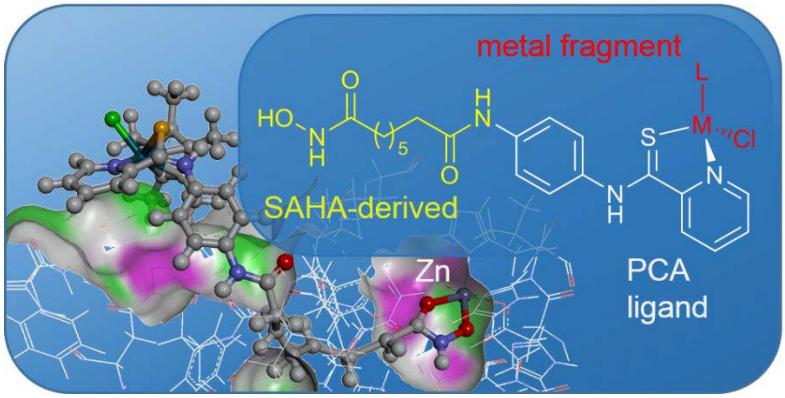
Pathogenic infections can cause serious diseases in humans and animals. For example, SARS-CoV-2, a novel coronavirus identified in December 2019, has already caused millions of infections around the globe. Current diagnostic methods for emerging pathogens are typically based on nucleic acid-based detection and antibody immune-complexation-based detection. However, these methods involve time-consuming protocols, are of limited sensitivity and can give high rates of false negative results. Organic electrochemical transistor (OECT) technology is of great interest for the detection of pathogens due to its high sensitivity, good stability, and ease of functionalisation with bio-probes. In this project, a cost-effective, sensitive, and selective OECT sensing device will be developed for the detection of pathogens from biological samples. The specific binding between the surface-bound bio-recognition probe and the biological target will cause the change in electric current, which will be used as a pathogen-presence readout. Such OECT sensing device will provide a rapid, easy-to-operate, point-of-care detection solution.

Supervisors:
Professor Jadranka Travas-Sejdic, j.travas-sedjci@auckland.ac.nz
Associate Professor Kean Aw, k.aw@auckland.ac.nz (Mechanical Engineering)
Dr John Taylor, ja.taylor@auckland.ac.nz (Biological Sciences)
Dr Bicheng (Amy) Zhu, bicheng.zhu@auckland.ac.nz

Metal-based Anticancer Agents: Design, Preparation and Analysis of the Modes of Action of Bioorganometallic Chemotherapeutics

More than 50% of cancer patients receive platinum-based chemotherapeutics, and many more inorganic compounds are widely used in the diagnosis and treatment of other diseases. This is owed to their specific properties such as tunable ligand exchange reactions, redox activity, unpaired electrons, and/or radioactivity. Bioorganometallic chemistry, i.e. the chemistry of compounds featuring at least one metal-carbon bond, is a thriving field of research and in particular the development of anticancer drugs based on organometallic moieties has received a lot of attention in recent years. While the modes of action of anticancer metallodrugs are crucially dependent on their interactions with biological molecules, we often lack an understanding of the targets and how the complexes are metabolized in biological environment.

My group designs, synthesizes and studies new anticancer agents, often with bioactive co-ligands, and we develop analysis methods using high-end instrumentation to investigate their modes of action. We have several projects available in this area for students with interest in synthetic and/or analytical chemistry and who have an interest in the drug development process in general.

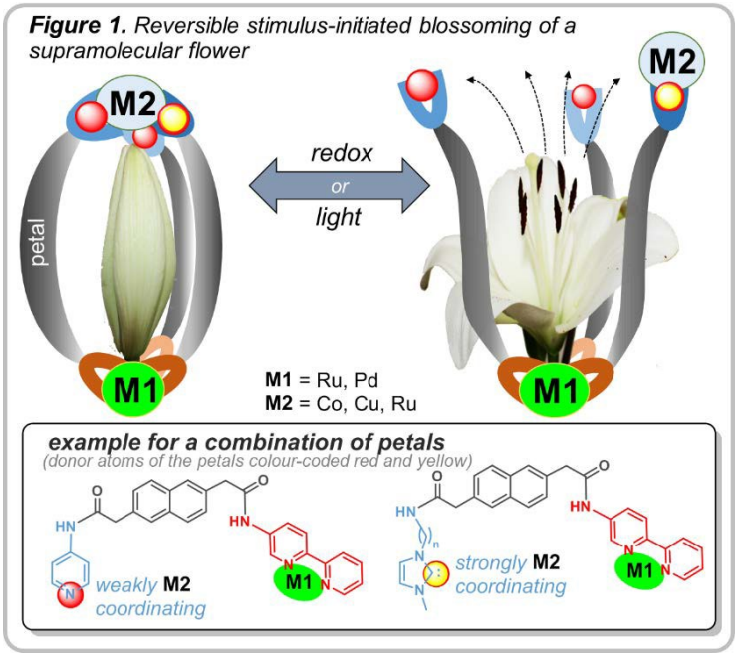


Hartinger et al., Angew. Chem. 2020, 59(34), 14609

Supervisor: Professor Christian Hartinger, c.hartinger@auckland.ac.nz

Stimulus-responsive Supramolecular Structures for Anticancer Drug Delivery

The formation of flexible supramolecular architectures in nature is key to the function of many biomolecules. Supramolecular structures arise from a defined number of building blocks that reversibly interact through weak forces (*e.g.* metal coordination, hydrogen bonding and electrostatic interactions), rather than by covalent bonds. Such interactions facilitate the formation of large, complex structures with specific biological functions. Inspired by this concept, synthetic supramolecular compounds based on metal complexes have been prepared (metallosupramolecular compounds) and have been used in catalysis, drug delivery, as ion sensors and as 'molecular containers'. However, most synthetic supramolecular compounds have been designed to be static. There are very few examples of specifically designed, discrete molecular containers with stimuli responsive architectures, as found in nature, and these are mostly limited to large less easily controlled structures such as functionalised cyclodextrins and polymers.



We design, synthesize and study new supramolecular compounds that are responsive to pH, light and redox reactions. We use high-end analysis methods to investigate the binding of guest molecules to the supramolecules and we investigate their release with a particular focus on the delivery to cancer cells. For this project, we are looking for motivated students with background in synthetic chemistry.
https://hartinger.wordpress.fos.auckland.ac.nz/marsden-project/

Supervisor: Professor Christian Hartinger, c.hartinger@auckland.ac.nz
Co-supervisor: Professor James Crowley (Otago University), jcrowley@chemistry.otago.ac.nz

Narrowing the gap between calculations and experiments in the electrochemical CO2 reduction reaction

Rational catalyst design is arguably the ultimate goal in heterogeneous catalysis research. In the last few decades, new computational methods have been developed to further our understanding of the catalytic performance of heterogeneous catalysts, which makes it possible to do a priori catalyst design using high-performance computing resources. However, there is still a large disagreement between theoretical prediction and experimental performance to truly revolutionise the chemical industry. The disagreement is mainly caused by the differences between the predicted catalyst structures from computational chemistry and the synthesised catalyst in the actual experiment. Understanding these false-positive predictions by collaborating with experiment scientist is necessary to refine the current computational chemistry framework and improvement the prediction accuracy.
In this project, the student will learn how to develop a high-throughput catalyst design method using the descriptor-based design framework and machine learning algorithm under the supervision of Dr. Ziyun Wang. The adsorption energy of intermediate states will be used as the descriptor, and the catalyst structure with the optimal adsorption energy will be chosen as potential candidates for experimental screening, carried out by the experiment collaborators. The student will analyse the catalytic performance and theoretical calculation to deduce any structure-to-properties relationship.

Further iterations will be performed to design a final catalyst with superior performance. The CO2 electrochemical reduction reaction (CO2RR) will be used as a model reaction in this project due to its significant technological importance.

Supervisor: Dr Ziyun Wang, ziyun.wang@auckland.ac.nz

School of Computer Science

Investigation of Computational Architecture for Edge AI

Edge Artificial Intelligence is a system that uses Machine Learning algorithms to process data generated by a hardware device without the connection of the Internet. A complete processing toolkit that allows on-device inference is highly desirable. It allows us to build products that are efficient, private, fast, and offline. Computer architecture for Edge Artificial Intelligence has become a popular research topic.

In this project, we explore the solution to the computer architecture for Edge Artificial Intelligence. The proposed solution can be categorized into three methodologies. First, we will apply Processing-in-Memory (PIM) techniques as it has been explored as a promising solution to tackle the data movement challenge in various applications. Second, we will apply a well-designed Non-blocking Network switch to connect the PIM blocks to reduce the latency and logic complexity for data movement. Third, we will design a compiler to capture the characteristics of the neural network model. The compiler can produce a sequence of micro-instructions to control the data movement and operations of PIM blocks.

Recently, the popular machine learning frameworks heavily rely on a variety of dedicated hardware implementations for their neural network operations. In contrast to conventional computing applications, the computational and memory resources of these neural network applications are mixed. The mixing of the computational and memory resources results in a significant amount of data movement. A well-designed Processing-in-Memory (PIM) architecture can prevent this memory bottleneck by providing fast near-data processing. By studying the characteristics of neural network models, we can determine the most appropriate size of memory for each PIM block. To provide an energy-efficient computation, the processing unit will employ fixed-point arithmetic. The batch normalization will be applied to reduce the loss of accuracy.
We can apply a non-blocking network switch to connect the PIM blocks. A non-blocking network switch is a design of crossbar switch to allow the connection between N inputs and N outputs in any permutations at various moments. By applying a non-blocking network such as the Benes network, we can achieve the maximum flexibility of data movement between the PIM blocks. However, only a subset of complete permutations is required for most popular neural networking models. A sub-optimal non-blocking network will be explored. By applying a simplified non-blocking network, the PIM architecture can still accommodate the data movement for most neural network models, and this can reduce the reduce latency and logic complexity of the crossbar switch for the non-blocking network.

Supervisor: Dr Chiu-Wing (Bruce) Sham, b.sham@auckland.ac.nz

Accelerating Chip Design with Machine Learning
Chip floorplanning plays an important role in the physical design of very large scale integration circuits. It plans the shapes and locations of the modules on a chip. It generates the physical layout of a computer chip, the result of which will greatly affect the overall performance of the final circuit. Chip floorplanning is a very time-consuming task and it takes a very long time (up-to a few months) to produce manufacturable layouts.

In this project, the student is going devise a reinforcement learning model to carry out the chip floorplanning process including place-and-route and timing and physical signoff analysis. The proposed method is believed to be used to design the next generation of artificial intelligence (AI) accelerators. The more powerful AI-designed hardware will fuel advances in AI. This creates symbiotic relationship between the two fields.

Supervisor: Dr Chiu-Wing (Bruce) Sham, b.sham@auckland.ac.nz

Accelerating the Process of Spatial Computation for the Housing Characteristics
In the study of housing characteristics, spatial computation is used to compute the proportion of house cohorts within a certain distance neighbourhood. This study exploits the proportion of a particular cohort of houses to the total number of houses within walking distance (both 0.5km and a 1.0km) to proxy the "urban ambience" effects. Two steps are involved in coming up with the proportion of a particular cohort of houses for every property in Auckland, namely 1) creating an N×N distance matrix for all properties in Auckland; and 2) performing the conditional spatial counting based on building cohort (i.e., counting number of buildings of a particular cohort to the total within a prescribed radius circle). Since there is a large volume of houses in the study, the typical methods may not be good enough to be used for this purpose. In this project, we are going to apply a novel data structure to store the data and a more innovated algorithm such as Delaunay triangulation to perform computation.

Supervisor: Dr Chiu-Wing (Bruce) Sham, b.sham@auckland.ac.nz

Mathematical and algorithmic challenges in phylogenetics
How did HIV evolve? Which vaccine will best protect against next season's flu? To answer these and other questions in the study of evolution, phylogenetic trees and networks play a crucial role. Phylogenetic networks are leaf-labelled rooted acyclic digraphs that are used to represent the evolutionary history of a set of present-day species. To accurately reconstruct phylogenetic networks, a deep understanding of their underlying mathematical structure is necessary. The goal of this project is to develop new theory and algorithms to unravel complex ancestral relationships between species without compromising accuracy. Of particular interest is the development of new parameterized and approximation algorithms to tackle some unanswered questions in the reconstruction and comparison of phylogenetic networks. Candidates are expected to have a strong background in graph theory or theoretical computer science.

Supervisor: Dr Simone Linz, s.linz@auckland.ac.nz

Applications of quantum annealing in computational biology
Phylogenetic (evolutionary) trees are widely used by biologists to represent ancestral relationships between species. Due to non-treelike events such as hybridization and horizontal gene transfer that cannot be captured by a single phylogenetic tree, the representation of evolution is now being generalized to phylogenetic networks which are leaf-labelled directed acyclic graphs. However, in contrast to algorithms for phylogenetic trees, many of the algorithms that are currently being used to reconstruct and analyse phylogenetic networks do not scale up well to large data sets. The purpose of this project is to develop new algorithms to reconstruct phylogenetic networks by using quantum annealing (implemented by the Advantage D-Wave machine). This model of quantum computing can solve native optimization problems and is well suited for this project. The project combines the development of the model, the proof of correctness and experimental testing on Advantage D-Wave. Candidates are expected to have a strong background in discrete mathematics and/or theoretical computer science. Knowledge in biology is not required.

Supervisors:
Professor Cristian S. Calude, cristian@cs.auckland.ac.nz
Dr Michael J. Dinneen, mjd@cs.auckland.ac.nz
Dr Simone Linz, s.linz@auckland.ac.nz

A Gamified Virtual Reality Tutor for Training Spatial Reasoning Skills
Spatial skills are a significant predictor of achievement in STEM subjects (Science, Technology, Engineering, and Mathematics). In contrast to many other cognitive abilities, spatial skills can be trained. However, it is unclear how to make training effective and enjoyable for a wide range of users. In this research, we will develop and evaluate a VR training tool for spatial skills, which will be based on recent research in pedagogy and neuroscience. In order to make the application engaging, it will contain gamification elements.

Supervisor: Dr Burkhard Wuensche, burkhard@cs.auckland.ac.nz

Automatic Generation of Formative Feedback for Computer Graphics Programming Assignments
Teaching and learning computer graphics are often considered challenging due to it requiring a diverse range of skills such as mathematics, programming, problem solving, and art and design. Assignments are a popular tool to support learning and to assess students' understanding. The value of such assignments depends on the ability to give fast (and ideally formative) feedback and enabling students to interactively explore the solution space. This is often a problem, in particular for large classes, where assignment marking can take many days or even weeks. By the time feedback is received students often don't remember details, and there is usually no opportunity to resubmit and hence little motivation to reflect on and correct mistakes.
In previous research we developed CodeRunnerGL, a tool for automatic assessment of OpenGL programming questions. The tool has been used in a class of about 300 students

for several years now and students perceive the tool as having significantly improved their learning.
In the proposed research we will extend CodeRunnerGL to automatically produce formative feedback. This means, if a student solution is incorrect the tool should provide feedback where the error is, and it should give hints how the error could be resolved (without displaying the correct solution).

Supervisor: Dr Burkhard Wuensche, burkhard@cs.auckland.ac.nz

AR/VR Embodied Spatial Training
Spatial skills are a significant predictor of achievement in STEM subjects (Science, Technology, Engineering, and Mathematics). In contrast to many other cognitive abilities, spatial skills can be trained. In this project we will investigate how spatial reasoning skills can be trained in AR/VR by physically interacting with virtual or augmented objects, and whether training effects are improved when using physical motions (e.g. hand gestures) rather than mouse interactions. In addition, we also want to investigate the role of haptic feedback on spatial training in an AV/AR environment.

Supervisor: Dr Burkhard Wuensche, burkhard@cs.auckland.ac.nz

Procedural Generation of Multi-Version questions for Computer Graphics Programming Assessments
Assessment is an important part of teaching and learning. For practical computer science courses programming questions are preferred as an assessment method. Programming assignments require the use of computers and internet access is often hard to control. This makes it easy to cheat, e.g., searching the web for solutions, using tools such as Chegg, and by using social media to discuss and exchange solutions with peers. The use of multi-version question is an effective way to detect and reduce the risk of cheating since any two students are unlikely to have the same set of questions.
In this project we will develop a program for procedurally generating programming questions for computer graphics assessments. The tool should enable instructors to set certain parameters for a question and from this, automatically generate a set of questions including sample solution, output images, and test cases. The information should be stored in an HTML file. The project will use CodeRunner and if possible, the generated HTML files should get imported into the CodeRunner question bank.

Supervisor: Dr Burkhard Wuensche, burkhard@cs.auckland.ac.nz

Prof. MIME – Multi-modal Intelligent Mathematics Education
Mathematics is a core subject in primary school and represents an essential foundation for many other disciplines. Unfortunately, mathematics scores of New Zealand students have been declining for over a decade. A popular approach for teaching mathematics is to use a multi-modal strategy (MMS), which combines numbers (calculate) with symbols (manipulate), words (communicate), story (apply), physical representations (do), and diagrams (visualise). While this approach has been used in classrooms for several decades, most computer-based tools use a more simplistic approach.

In this project we will develop a multi-modal intelligent tool targeted at primary school students, which will use computer vision and AR technologies to improve mathematics education. The application will apply concepts from intelligent tutoring systems to adjust content and presentation in order to keep learners motivated and challenged.

Supervisor: Dr Burkhard Wuensche, burkhard@cs.auckland.ac.nz

Scalable machine learning with locality sensitive hashing

Locality-sensitive hashing (LSH) is a primary algorithmic tool for many computer science applications in high dimensions. It has been shown that LSH can significantly reduce the complexity of many machine learning models, including Support Vector Machine, Nearest Neighbor Search, Deep Learning… The project will exploit recent development of LSH to further advance well-known machine learning algorithms on large-scale data sets.
Prerequisites: Experience with high-performance programming in C/C++, Python, Matlab

Supervisor: Dr Ninh Pham, ninh.pham@auckland.ac.nz

Exploring Embodiment in Immersive XR

How can audio-visual effects in virtual and mixed-reality change our sensory perception and physical activity? "Dancing in/Dancing With the Digital" is an interdisciplinary project exploring the alternative sense of embodiment produced by real-time, immersive technologies. Working with partners from the School of Computer Science, the Auckland Bioengineering Institute and the Dance Studies department, you will have the opportunity to design and co-create immersive experiences that seek to increase creative movement potential and engage multisensory awareness in their audiences, with an aim to better understand human movement and perception in XR realms. Outputs include practical and creative VR/AR prototypes allowing for virtual sensing and moving together.

Supervisors:
Dr Danielle Lottridge, d.lottridge@auckland.ac.nz
Dr Becca Weber, b.weber@auckland.ac.nz (Dance Studies)

Data-quality driven database design

Database design aims at organizing data and its relationships in order to process data efficiently. Traditional database design only addresses the integrity of data. The goal of this project is to develop a mathematically rigorous and robust framework to incorporate other data quality dimensions into the design of databases. If successful, data will be fit for purpose by design and therefore form the foundation for deriving meaningful insight from higher quality data that is trusted. Candidates should have a strong background in discrete mathematics, in particular logic and complexity theory, but also a drive to apply this background to data and develop tools that bring new theories to life. It is expected that this research will lead to outputs in the leading database conferences and journals, such as ICDE, VLDB, SIGMOD, ACM Transactions on Database Systems, IEEE Transactions on Knowledge and Data Engineering, and The VLDB Journal.

Previous work of the supervisor on this subject includes:

- Ziheng Wei, Sebastian Link: Embedded Functional Dependencies and Data-completeness Tailored Database Design. ACM Trans. Database Syst. 46(2): 7:1-7:46 (2021)
- Sebastian Link, Ziheng Wei: Logical Schema Design that Quantifies Update Inefficiency and Join Efficiency. SIGMOD Conference 2021: 1169-1181
- Henning Köhler, Sebastian Link: SQL Schema Design: Foundations, Normal Forms, and Normalization. SIGMOD Conference 2016: 267-279

Supervisor: Professor Sebastian Link, s.link@auckland.ac.nz

Data profiling and sampling

Data profiling refers to activities that derive meta-data from given data sets. In this project, we are interested in developing efficient algorithms for the discovery of advanced classes of database constraints from given data sets. The application of the discovered constraints in data cleaning, integration, and schema design will also be investigated. Sampling approaches that help with the identification of constraints that are meaningful for underlying application domains will be combined with the discovery process. If successful, sound foundations for automating important tasks in data preparation will be established. This can save considerable resources in any data science projects. Candidates should have a strong background in discrete mathematics, in particular logic and complexity theory, but also a drive to apply this background to data and develop tools that bring new theories to life. It is expected that this research will lead to outputs in the leading database conferences and journals, such as ICDE, VLDB, SIGMOD, ACM Transactions on Database Systems, IEEE Transactions on Knowledge and Data Engineering, and The VLDB Journal.

- Ziheng Wei, Sven Hartmann, Sebastian Link: Algorithms for the Discovery of Embedded Functional Dependencies, The VLDB Journal, 2021.
- Henning Koehler and Sebastian Link: Possibilistic Data Cleaning, IEEE Transactions on Knowledge and Data Engineering, 2021
- Ziheng Wei, Uwe Leck, Sebastian Link: Discovery and Ranking of Embedded Uniqueness Constraints. Proc. VLDB Endow. 12(13): 2339-2352 (2019)

Supervisor: Professor Sebastian Link, s.link@auckland.ac.nz

School of Environment and School of Chemical Sciences

Risk assessment of nanopesticides

A variety of nano-delivery systems for pesticides, called nanopesticides, are being proposed and evaluated to improve current agricultural practices. Such delivery systems can be made of a range of materials, including inorganic (e.g. metals, metal oxides, clays), organic (e.g. polymers, lipids), and biological materials (e.g. inactive viruses). The potential applications and benefits are likely to be enormous. However, agroecosystems are incredibly diverse and complex, and designing viable and safe products for application in the field is challenging. This project looks at the fate and effects of a series of nanopesticides relative to currently used products. Laboratory experiments will be conducted across a range of conditions relevant for ecological and/or

human health risk assessment. The results will guide the design of more sustainable nanopesticides and help regulators in assessing the potential risk associated.

Supervisor: Associate Professor Melanie Kah, melanie.kah@auckland.ac.nz

Fate of soluble polymers in the environment
Water-soluble polymers are used in a wide array of applications that result in their release into the environment. For instance, water-soluble polymers are increasingly used as co-formulants for pesticide formulations that are applied in agriculture. The environmental fate of water-soluble polymers is mostly unknown, which makes their risk assessment highly uncertain. An important challenge is that polymers are difficult to detect in the environment and standard experimental approaches are often unsuitable. This project will address these knowledge gaps by 1) developing novel and suitable approaches, and 2) generating experimental data on the environmental fate of a series of soluble polymers in soil and in water. The knowledge generated will be essential 1) to assess the risk that soluble polymers currently pose to the environment and 2) to suggest more sustainable alternatives.

Supervisor: Associate Professor Melanie Kah, melanie.kah@auckland.ac.nz

Environmental fate and remediation of PFAS
Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are a group of >9,000 exceptional chemicals. They are now well recognised global contaminants due to their toxicity and stability (PFAS are also known as "forever chemicals"). The most common approach for treating PFAS contaminated water currently relies on sorption to engineered sorbents. What to do with the spent sorbent is a controversial question as current practices (e.g. incineration and disposal into landfill) are associated with risks in the longer term. Our analysis of the recent literature has identified a number of knowledge-gaps that should be urgently addressed to design sustainable remediation solutions, including an improved management of spent sorbent materials. This project will address some of these gaps with experiments conducted at the laboratory and pilot scale.

Supervisor: Associate Professor Melanie Kah, melanie.kah@auckland.ac.nz

Department of Exercise Sciences

Biomechanical Simulation for Children with Cerebral Palsy
Cerebral palsy (CP) is a well-recognized neurodevelopmental condition resulting from brain injury, beginning at early childhood, and lasting the lifespan. It can lead to progressive and permanent musculoskeletal disorders with the growth in most affected children. Ankle and foot equines are one of the most common deformities among patients with CP and receives a lot of attention from therapists and surgeons. The main purposes of this project include: 1) Using biomechanical principles and methods to improve clinical gait analysis; 2) Using medical images to create patient-specific musculoskeletal models and conduct finite element modelling for surgical outcome prediction. The applicant(s) must have a Master's degree in biomedical engineering, mechanical engineering, sports science, or a related area.

Supervisor: Dr Yanxin Zhang, yanxin.zhang@auckland.ac.nz

Development of an intelligent system for automated motor impairment assessment and risk prediction

Clinical assessment is important not only to quantify the severity of motor impairment, but to support the timely adjustment of appropriate clinical interventions. Advances in technology have allowed for valid and reliable measurement of biological signals, which can provide quantitative data that can be used by clinicians for objective decision-making. The project aims to develop an intelligent system for automated motor impairment assessment, which will include a portable motion capture sensor, a biomechanical model, and an expert system based on machining learning algorithms for risk prediction.

The applicant(s) must have a Master's degree in biomedical engineering, mechanical engineering, computer science, epidemiology, or a related area.

Supervisor: Dr Yanxin Zhang, yanxin.zhang@auckland.ac.nz

Department of Mathematics

Making sense of the complexity of university-level mathematics education and bettering its teaching and learning

University courses in mathematics gained a reputation for being intense and difficult for many students. Large classes, dense curricula, mathematical content that is conveyed in a way that is substantially different from the one that students are familiar with from high school – these and many other factors contribute to the complexity of students' learning of mathematics. This is a large-scale project with multiple components aiming to: understand the complexity of the processes students go through when studying university-level mathematics and explore the impact of innovative learning-and-teaching environments on these processes. PhD students who join this project might be interested in exploring teaching and learning processes that unfold in undergraduate courses in analysis, abstract algebra, combinatorics, graph theory, game theory, number theory, or topology, possibly with a focus on how undergraduates work with definitions, generate examples, prove, solve, and pose problems.

Supervisor: Dr Igor' Kontorovich, i.kontorovich@auckland.ac.nz

School and university mathematics education: Students' usage of online forums for mathematics learning

On the one hand, there is evidence of a decline in students' interest in mathematics. On the other hand, there are many online mathematical forums with rich and insightful discussions, many posts in which are contributed by school and university students. Some of these discussions are tightly linked to homework assignments that students get in a classroom. Other discussions reflect students' genuine interests in mathematics and a desire to make sense of it. Surprisingly, the widespread phenomenon of student (and teachers') usage of open online mathematical forums has not been explored yet. PhD students who join this project might be interested to explore the topics that are discussed in open online mathematical forums while attending to their communicational patterns. It is also important to understand how students make use of such forums in respect to their school and university studies,

and how teachers should account for these usages in their teaching, for instance, when designing homework assignments.

Supervisor: Dr Igor' Kontorovich, i.kontorovich@auckland.ac.nz

Mathematical physiology and dynamical systems

Oscillations and waves in the concentration of free cytosolic calcium are one of the most important intracellular signalling mechanisms, controlling a wide range of cellular functions, including gene expression, cell differentiation, secretion, and water transport. However, although they are physiologically important, these periodic phenomena are difficult to study using experimental techniques alone; their complexity is so great that only limited understanding can be gained in the absence of quantitative approaches. Thus, over the past few decades the study of calcium dynamics has developed into an important area of interdisciplinary research.

In collaboration with major international experimental groups in the USA, Japan and Europe, our research group is interested in constructing new mathematical models for calcium oscillations. These models allow us to make predictions that inform and guide further experiments, ultimately leading to a better understanding of the underlying physiology. Members of our research group also work on developing new mathematical ideas useful for the analysis of a wide class of physical and biological models, including our calcium models.

We welcome queries from students with a strong background in mathematics and an interest in cell physiology, although no prior background in physiology is required.

Supervisors:
Professor James Sneyd, j.sneyd@auckland.ac.nz
Professor Vivien Kirk, v.kirk@auckland.ac.nz

Applications of post-quantum cryptography

Due to the potential threat of quantum computers, the research community is re-evaluating the security of a number of protocols and systems in widespread use. The project will leverage the NIST post-quantum standardization process to form a clear picture of the current state of post-quantum crypto. The project will develop new lightweight solutions for certain applications such as the internet of things (IoT).

Required skills and experience: Background in either Engineering, Computer Science or Mathematics. Good mathematical knowledge and understanding of rigorous mathematical thinking. Basic knowledge of cryptography and information security.

Supervisor: Professor Steven Galbraith, s.galbraith@auckland.ac.nz

Department of Physics

Bacteria detection using quantitative fluorescence

Bacteria are everywhere and are involved in many processes relevant to our everyday life, yet it is hard to monitor accurately and in real-time bacterial concentration. We have been utilising fluorescence and microfluidics to develop optofluidic methods for near-real time enumeration of low concentrations of bacteria.

The next challenge is to be able to identify the specific types of bacteria using these optofluidic methods. This research will be carried out in collaboration with microbiologists who will provide samples and knowledge of microorganisms and bacterial processes.

Supervisors:
Associate Professor Frederique Vanholsbeeck, f.vanholsbeeck@auckland.ac.nz
Dr Cushla McGoverin, c.mcgoverin@auckland.ac.nz

Multimodal optical imaging
Better understanding of the interplay between structure and chemistry is crucial to deepening our understanding of biological tissues, especially their mechanical properties. This project will involve the design and construction of an instrument for the simultaneous collection of optical coherence tomography (OCT), Raman and near-infrared spectroscopy data. OCT, the light-based analogue of ultrasound, imparts information about the structure of a sample. Raman and near-infrared spectroscopies are complementary vibrational spectroscopic methods which impart chemical information. Using these three techniques simultaneously will enable interrogation of both the structure and chemistry of a sample.

Supervisors:
Associate Professor Frederique Vanholsbeeck, f.vanholsbeeck@auckland.ac.nz
Dr Cushla McGoverin, c.mcgoverin@auckland.ac.nz

Microresonator frequency combs
Optical frequency combs are laser light sources whose spectrum is composed of numerous equidistant lines. They have had a transformative impact in the field of spectroscopy, enabling experimental measurements with astonishing precision. In 2007, a remarkable new method of frequency comb generation was demonstrated: low-power continuous wave laser light could spontaneously transform into a broadband frequency comb when coupled into an ultra-high-quality microresonator. Because of their unique characteristics, such "microresonator frequency combs" have the potential to revolutionize a number of applications ranging from telecommunications to biomedical imaging, and they have accordingly attracted considerable research interest over the last decade. We run an extensive experimental research program on microresonator frequency combs. Details of individual projects can be found at our website: www.laserlab.auckland.ac.nz

Supervisor: Associate Professor Stuart Murdoch, s.murdoch@auckland.ac.nz

School of Psychology

Investigating vocabulary development in Chinese-English bilingual children in NZ
Research indicates that the number and type of words bilingual children have in their two languages differ to that of their monolingual peers in either language. Little research has been undertaken to investigate this question with the pairing of Chinese (Putonghua) and English-speaking children.

This study will be a first of its kind in investigating bilingual children's knowledge of words in Chinese and English. The study will investigate this question with either preschool (3-5 years) or early primary school (5-6 years) children.

Supervisor: Dr Elaine Ballard, e.ballard@auckland.ac.nz

Investigating any aspect of grammatical development in Chinese-English bilingual children in NZ

There is very little research into the syntactic development of Chinese and English in bilingual children. This will be a landmark study investigating an aspect of grammatical structure (e.g. tense/aspect marking, pronouns) in children's language development in their two languages. The study will investigate this question with either preschool (3-5 years) or early primary school (5-6 years) children.

Supervisor: Dr Elaine Ballard, e.ballard@auckland.ac.nz

Performance of Chinese (Putonghua and/or any other varieties of Chinese) speaking adults on the Chinese and English versions of the Boston Naming Test

The Boston Naming Test is a picture naming assessment used to diagnose language impairment. The test has been translated into both Cantonese and Mandarin, but it has not been tested out extensively on healthy Chinese speaking populations resident in a Western country. This study will gather data from adult speakers so that the test can be standardised for Chinese populations resident in New Zealand. Students will gather data from either Chinese variety or both varieties.

Supervisor: Dr Elaine Ballard, e.ballard@auckland.ac.nz

Chinese language acquisition in second language learners

With China now a global power many New Zealanders have become interested in learning Mandarin. However, they may struggle with aspects of the language (tones, consonants, specific grammatical structures). In this study one aspect of Chinese that is problematic to second language learners of the language will be investigated.

Supervisor: Dr Elaine Ballard, e.ballard@auckland.ac.nz

Department of Statistics

Bayesian approaches to estimating the stochastic gravitational wave background

The planned ESA space-based gravitational wave detector LISA will be operating in the low-frequency regime allowing it to detect gravitational signal from the stochastic gravitational wave background (SGWB). The SGWB is the gravitational analogue to the cosmic microwave background and results from a large number of weak, independent, and unresolved sources of astrophysical and cosmological origin. An observed SGWB would provide a wealth of information about the universe.

This project aims at developing novel Bayesian nonparametric methods for estimating the power spectrum of the SGWB. A good knowledge of and interest in Bayesian inference, MCMC techniques, and time series as well as good programming skills and knowledge of R/Python are essential. This project would be suitable to students of statistics and/or physics. This project will give an opportunity to be involved in an international ESA-led collaboration, see https://www.gravity.ac.nz/people/

Supervisors: Professor Renate Meyer, renate.meyer@auckland.ac.nz
Nelson Christensen, Astrophysics, Observatoire de la Cote d'Azur, nelson.christensen@oca.eu

Disease risk prediction using deep learning techniques

The use of human genome discoveries and other established factors for predicting disease risk is an essential step in the modern quest for precision medicine. Emerging high-dimensional multi-layer omics data has provided unprecedented opportunities for systematically investigating the predictive effects of biomarkers and their interplay at various molecular levels. However, the high-dimensionality, regulatory dependencies among different omics layers, and complex relationships between predictors and disease outcomes have brought tremendous analytical challenges. New methods and software are urgently needed. The overall goal of this project is to develop explainable deep learning models that can reduce data dimension with theoretical justifications, efficiently integrate heterogeneous multi-omics data, and achieve the state-of-the-art prediction performance.

Supervisor: Dr Yalu Wen, y.wen@auckland.ac.nz

Properties of the One Standard Error Rule

The 1-SE rule is a widely-used heuristic modification to help avoid overfitting based on applying a classifier to test data. It is a very popular method in data science and machine learning. However, its properties have received little to no theoretical attention. The aim of this work is to derive the theoretical properties of the 1-SE rule. As well as obtaining its asymptotic properties, we wish to propose practical guidelines to make best use of the rule.

Supervisor: Dr Thomas Yee, t.yee@auckland.ac.nz

Vector Generalized Linear Mixed Models

The class of generalized linear mixed models (GLMMs) follows by adding random effects to GLMs, and they are very widely used. The aim of this research topic is to add random effects to the class of VGLMs, which is very large. Thus random effects capabilities could be added to many statistical models simultaneously. Several possible estimation algorithms to be considered include joint maximization methods such as Schall (1991, Biometrika) and quasi-likelihood estimators, Monte Carlo variants of the Newton-Raphson and EM algorithms, restricted maximum likelihood, the Laplace approximation, and adaptive Gaussian quadrature. To fully develop new algorithms for VGLMMs it is expected that the function vglmm() be written and added to the VGAM R package.

Supervisor: Dr Thomas Yee, t.yee@auckland.ac.nz

Topics in Information Geometry
Information geometry, based on differential geometry in pure mathematics, offers deep insights into certain areas of statistics. It provides a parameterization-independent approach to statistical estimation of parametric models that operates on flat or curved manifolds. This project is to explore parameter space dynamics of distributions based on differential geometrical ideas, e.g., tangent spaces, statistical curvature, tensors, and asymptotic theory. It would suit a student with a strong background in calculus/analysis and mathematical statistics. The background to this topic includes the work of Amari, Barndorff-Nielsen and Cox, and Efron, amongst many others.

Supervisor: Dr Thomas Yee, t.yee@auckland.ac.nz

Department of Statistics and Department of Physics

Locally stationary time series with applications to Bayesian modelling of LISA noise.
This project aims to develop Bayesian parametric and nonparametric approaches to modelling the second order properties of locally stationary time series. The main objectives are to further develop and scale up existing techniques to large data sets and develop novel extensions from univariate to multivariate time series. The developed techniques will be tested and applied to simulated data expected to be observed by the future space-based gravitational wave observatory LISA.
This project could be suitable for either a statistician or a physicist with interest in data analysis and will give an opportunity to be involved in an international ESA-led collaboration, see https://www.gravity.ac.nz/people/.

Requirements**:** Experience with time series analysis, Bayesian statistics and/or gravitational wave data analysis. Good programming skills and knowledge of R or Python are essential.

Supervisor: Professor Renate Meyer, renate.meyer@auckland.ac.nz

Variational Bayesian methods for nonparametric spectral density estimation
Nonparametric priors based on the Dirichlet process have wide applications in applied Bayesian inference and machine learning. However, Markov chain Monte Carlo techniques for sampling from the posterior distribution can be very computationally expensive and time-consuming. This project aims to investigate and develop variational inference for Dirichlet process mixtures. Variational Bayesian methods are deterministic algorithms that instead of sampling from the exact posterior distribution optimize the parameters of an approximating distribution. The main objective is to investigate and develop variational inference for nonparametric spectral density estimation of stationary time series.
Requirements: Experience with Bayesian statistics, machine learning and sound programming skills.

Supervisor: Professor Renate Meyer, renate.meyer@auckland.ac.nz

General Opportunities

The Liggins Institute has a diverse range of doctoral research projects areas spanning pregnancy, perinatal and maternal health research, childhood growth, influence of the early life environment on later disease, adolescence as a window for transgenerational non-communicable disease risk reduction, scientific and health literacy, the microbiome, nutrition, obesity and diabetes, genome biology and cancer research. A list of Liggins Institute supervisors with current postgraduate research opportunities can be found here.

The impact of short chain fatty acids on regulatory T cells in term and premature neonates

The neonatal immune system rapidly needs to adapt to the extrauterine environment in the first few weeks of life. Regulatory T cells (Tregs) play an important role in fine-tuning the appropriate level of immune reactivity and tolerance in this period. In previous animal experiments, short chain fatty acids (SCFAs), in particular propionate and butyrate, were described to play an important role in promoting Treg differentiation and proliferation. In this project, we aim to identify how various SCFAs influence the suppressive capacity of Tregs and the development of their subtypes in cord blood samples of term and premature neonates in comparison with a control group of healthy adults. Peripheral blood mononuclear cells will be isolated and cultured in the presence of SCFAs under various experimental conditions. Regulatory T cells will be phenotyped using flow cytometry. Mixed lymphocyte reactions (MLRs) will be used to assess the suppressive capacity of Tregs. The above experiments will help us better understand the development of the adaptive immune system with a specific focus on factors orchestrating the expansion of the Treg pool in the early neonatal period.

Supervisor: Dr Gergely Toldi, gergely.toldi@auckland.ac.nz

Application of novel antagonists of the growth hormone signalling in cancer
Radiotherapy, while an important treatment route for many cancers, doesn't work for all patients and resistance to therapy is a still major clinical obstacle. One approach to overcome this is to combine radiotherapy with agents that radiosensitise tumour cells, and for many common cancers, adding novel molecularly targeted agents to radiotherapy tangibly improves outcomes in both the preclinical and clinical setting.

The growth hormone (GH) signalling pathway has emerged as an important mediator of tumour development. GH is a multifaceted hormone that is essential for normal longitudinal growth and plays diverse roles in tissue and organ development, metabolism, cardiac function, and neural development. However, increasingly this hormone axis has been implicated in cancer. Expression of GH is detectable in a variety of different human cancers and is associated with reduced overall survival for cancer patients. In xenograft studies we have shown that agents that block the GH receptor are a new class of radiosensitiser. This project will test the efficacy of a novel inhibitor of GH signalling in preclinical cancer studies.

Supervisor: Associate Professor Jo Perry, j.perry@auckland.ac.nz