THE UNIVERSITY of ADELAIDE

Adelaide Summer Research Scholarships

School of Electrical and Electronic Engineering

PROJECTS OFFERED FOR 2018-19

Algorithms for Measuring Sleep Health

Sleep performs important restorative functions for brain and body. Since we spent about 1/3rd of our lives asleep, sleep disturbance can seriously affect emotional wellbeing, cognitive performance and cardiovascular health. It is therefore important to monitor sleep if issues are suspected. Multichannel sleep recordings, performed at home or hospital, acquire a number of physiological signals throughout the night, creating large volumes of biological data. Automated algorithms are required to process these signals and deliver diagnostic information to aid clinical decision making. In this project, we will analyse nasal airflow signals obtained during a large, international randomized trial involving >2,000 patients to create a robust algorithm for detecting airflow limitations. This project will develop students' skills in biomedical signal processing using Matlab and background knowledge in sleep physiology.

Supervisors: A/Prof Mathias Baumert and Dominik Linz

Modelling the Protection of Critical Infrastructure

In recent times, the problem of securing critical public assets such as power grids, water distribution systems, communications systems and transportation networks has become of significant importance to policy makers. In this project, game theoretical methods will be developed and applied to example problem domains. The project will develop the students' skills in modelling and optimisation which are key attributes of significant demand to employers.

Supervisor: Prof Lang White

Classifying Network Traffic Flows with Deep-learning

Deep-learning or Deep Neural Networks has gained prominence in recent years in a range of application areas, including image classification, speech recognition, self-driving cars, and was successfully adopted by IBM and Google for their artificial intelligence projects in winning competitions such as Chess and Go. This project involves developing deep learning techniques for classifying internet communications traffic for monitoring and management of networks and their infrastructure. Malicious attacks against computer networks of businesses, government agencies and the wider Internet infrastructure is another critical area of concern due to their increasing frequency and resultant damage.

This project expands upon current network classification R&D projects sponsored by the Defence Science & Technology Group since 2014. The goal of this project is to extend existing research and techniques for classification of sparsely labelled network data. In discussion with the successful student(s), this includes expanding the deep-learning approach with graph theoretic methods, self-taught or transfer-learning concepts.

The project provides students with the opportunity to:

- Gain knowledge within the data sciences domain, specifically deep-learning technologies
- Develop and adapt machine-learning techniques for application to network traffic flows
- Gain experience in utilising the university's super computing platform (HPC) to deploy traffic classifiers and conduct experiments
- Collaborate and write a research paper to capture the research work undertaken

Supervisors: Dr Hong Gunn Chew and Dr Adriel Cheng

Radar Cross Section Measurement of Weapons at Terahertz Frequencies

The terahertz range spans 0.1 and 10 THz. It defines a transition between the electronics and photonics domains—the frequency range is at the upper bound of electronics and the lower bound of photonics. For this very reason, in the past the band has been perceived as a terahertz gap due to the lack of efficient generation and detection approaches. Over a few decades, a myriad of sources and detectors have become mature to tap into unique opportunities in this frequency range. One potential application is stand-off seeing-through radar detection for security purposes. Weaponry or contraband hidden under cloth could be detected from afar without involving harmful X-ray radiation. This project will embark on measuring the monostatic radar cross section of knives and guns at the frequency range of 220-330 GHz where the atmospheric absorption is relatively low. The project will establish a knowledge base for future development of terahertz radar.

Supervisor: Dr Withawat Withayachumnankul

Terahertz Waveguides Made of Ceramic-based Polymer Filaments

The terahertz range spans 0.1 and 10 THz. It defines a transition between the electronics and photonics domains—the frequency range is at the upper bound of electronics and the lower bound of photonics. For this very reason, in the past the band has been perceived as a terahertz gap due to the lack of efficient generation and detection approaches. Over a few decades, a myriad of sources and detectors have become mature to tap into unique opportunities in this frequency range. Much has yet to be done in this area towards integrated high-performance platforms for consumer applications. A core component that underpins any integrated platform is the inter-connect, i.e., wave guiding structures. A large number of terahertz waveguides have been proposed with different trade-offs related to bandwidth, dispersion, confinement, losses, and fabrication complexity. Here we have identified novel ceramic-based polymer filaments that could carry terahertz waves with good performance. This project will embark on systematic characterisation of this novel material in relation to its wave guiding performance. The developed knowledge could be used for designing other important components for terahertz waves.

Supervisor: Dr Withawat Withayachumnankul

Projects offered in collaboration with Physics and IPAS

Towards Noiseless Quantum Sensing

Quantum Sensing based on superconducting devices currently enables the production of extremely high-performance magnetometers with quantum-limited noise levels. Improvements to device sensitivity, linearity and bandwidth by improving device design will guarantee superior magnetic sensing that can outperforms every conventional detector. This project aims at the introduction of a revolutionary combination between different tools to develop new architectures that incorporate the

quantum behaviour of superconducting parameters into the sensor designs. This project will be done in collaboration with the largest Australian micro-electronics company, Silanna, and his Chief Scientist Prof Atanackovic that has recently installed a lab within the ECMS grounds.
Supervisors: Prof Christophe Fumeaux and Dr Giuseppe Tettamanzi

Atom-by-Atom Construction of an Error-free Environment for a Quantum Pump
Single-electron pumps are quantum objects that can be used to generate electrical currents by controlling electrons one-by-one (see https://www.adelaide.edu.au/news/news101002.html). In these devices, the Coulomb potential and the coupling between external voltage gates and the quantum states can be used to generate accurate electronic currents. Our group has recently developed some of the most interesting concepts in this field (http://iopscience.iop.org/article/10.1088/1367-2630/16/6/063036/meta, https://www.nature.com/articles/srep44371?WT.feed_name=subjects_semiconductors and https://pubs.acs.org/doi/abs/10.1021/nl500927q) and plan to continue this research also by using atomically precise devices (see https://pubs.acs.org/doi/10.1021/acsnano.6b06362 and https://pubs.acs.org/doi/abs/10.1021/acsnano.7b00850). This project will initially explore possible modelling capabilities in collaboration with researchers from the UNSW, Sydney, PTB Braunschweig, Germany and Latvia University.
Supervisors: Prof Christophe Fumeaux and Dr Giuseppe Tettamanzi

Modelling of the Propagation of Electro-Magnetic Signals into Peripheral Nerves Due to Graft-antenna
Peripheral nerve injuries are difficult to treat; brief Electro-Magnetic (EM) stimulation of injured nerves is an emerging therapy that can relieve pain and can enhance nerves regeneration, however the microscopic mechanisms behind the propagation of EM signals in these biological materials are yet to be clarified. In this project, we plan to model the conduction of EM signals into the nerves. This project will partially be done also in collaboration with researchers from the School of Physical Sciences of the University of Adelaide, UWS, NSW and the UNSW, Sydney.
Supervisors: Prof Christophe Fumeaux and Dr Giuseppe Tettamanzi

Modelling Physical Behaviours of the Most Precise Clock Ever Built
Timing precision is critical in many sensing, communication and computational tasks. The Sapphire Clock technology produces a microwave signal that performs up to 1000 times better than any competing technology, however, although this technology has been developed for many years, some of its microscopic behaviours have not yet been clarified. This project aims to study models that explain the Electro-Mechanicals effects that can take place into the systems. This will be done also in collaboration with Cryoclock Pty Ltd, as such there is the possibility of top-up scholarships from industry on top of the ECMS one.
Supervisors: Prof Christophe Fumeaux, Dr Giuseppe Tettamanzi and Prof Andre' Luiten

Modelling the causes of the regeneration of Peripheral Nerves under the Electro-Magnetic Excitation
The microscopic mechanisms behind the propagation of EM signals in biological materials such as peripheral nerves are yet to be clarified. This is important because peripheral nerve injuries are very

difficult to treat and one of the few techniques that works are the ones based on the use of brief Electro-Magnetic (EM) stimulation of injured nerves. These emerging therapies that can relieve pain and can enhance nerves regeneration.

In this project, in collaboration with the School of Physical Sciences of the University of Adelaide, UWS, NSW and the UNSW, Sydney we plan to model the conduction of EM signals into the nerves. UNSW, Sydney.
Supervisors: Prof Christophe Fumeaux and Dr Giuseppe Tettamanzi