1. RF ablation guarding circuits for EIT

Synopsis:
Intracardiac and endovascular ablation therapies are widespread in their use in the treatment of a variety of cardiac arrhythmias as well as renal artery denervation. Currently radiofrequency energy is used to form thermal lesions in the vast majority of such ablations, however cryoablation, laser, high intensity focused ultrasound and microwave are emerging as alternative energy sources. Currently, there is no direct way to monitor in real time the delivery of these energies to the myocardium or vascular wall to determine whether an adequate lesion has been formed or whether there is risk of collateral damage to adjacent structures.

In collaboration with Westmead Cardiology, we have developed a Thermochromic Endocardial Phantom for ablation catheter testing. In the next step of this research, we plan on using Electrical Impedance Tomography (EIT) for real time tissue damage monitoring during an ablation. In this research, it is imperative to have a guarding/filtering circuit at each EIT electrode to mitigate the effect of RF ablation as EIT works at 50 kHz while RF ablation is usually between 450 kHz to 500 kHz at 20-36W. Thus, the energy delivered by the RF ablation is detrimental to the electronics of the EIT system.

The student participating in this project will develop prototype for the guarding circuit and testing its efficacy with medical ablation generators and EIT systems.

Due to time constrains of our project, we would prefer a dedicated student who is adept in electronics with knowledge of medical equipment, experience in PCB design and would be willing to work over the summer. You will be working with a team of engineers and cardiologists with ample opportunities to learn more about medical electronics in a clinical settings.

2. Simulation of an inside-out EIT system for temperature monitoring during an ablation

Synopsis:
Intracardiac and endovascular ablation therapies are widespread in their use in the treatment of a variety of cardiac arrhythmias as well as renal artery denervation. Currently radiofrequency energy is used to form thermal lesions in the vast majority of such ablations, however cryoablation, laser, high intensity focused ultrasound and microwave are emerging as alternative energy sources. Currently, there is no direct way to monitor in real time the delivery of these energies to the myocardium or vascular wall to determine whether an adequate lesion has been formed or whether there is risk of collateral damage to adjacent structures.

We would like to investigate possible use of Electrical Impedance Tomography (EIT) for real time monitoring of tissue damage during a cardiac ablation. Current technology of EIT has very low resolution. One possible way to increase the resolution is to bring the
entire system closer to the site of interest. In this case, an EIT array can be inserted into
the esophagus to monitor changes in tissue during a cardiac ablation.

In the first instance, we would like to test the feasibility of this idea computationally. This
project will first develop a Finite Element Model of the problem, perform simulations with
various electrodes arrangements and current injections patterns, and report on the
efficacy of such methods, i.e answering the question of how much more sensitive an
inside-out system is to a typical EIT arrangement (with electrodes on the body surface),
how sensitive to heating, localisation of heated structures, etc.

This challenging project would suit a student with particular strong Matlab and
computational skills. You will be working closely with a PhD student who will be
available to help you start up with the project and help with code debugging. You will be
working with a team of engineers and cardiologists with ample opportunities to learn
more about medical electronics in a clinical settings.

3. Total body nitrogen device development
Measuring protein energy malnutrition is vital in children as it effects development and
can lead to total organ failure. Gamma neutron capture analysis is established for
adults but the use of radiation is a concern in children. This issue has been resolved
with device being developed at Westmead hospital and it is unique in the

This project is to update the control electronics of the scanning table used by the
device. Software to control servo motors from Galilmc and sensors needs to be written
in the command software, possibly with the provided communication libraries in  C++,

4. Software based visualisation of accelerometer data from limb movements
The biomedical sciences group at Cumberland campus are developing a new method to
track limb movements with accelerometers in subjects with movement disorders
(Parkinson’s, spasticity following stroke and rheumatoid arthritis). Muscle reflexes
strongly influence the biomechanics of the limb and thus performance in different tasks.
New measures of limb biomechanics (joint stiffness, force and velocity relationships) at
several locations on the limb are measured with accelerometers. Currently this data is
displayed as a time seriers. The task in this project is to plot this data in 3D and provide
a useful visualisation for the subjects and researchers.

5. ARM programming for medical devices
A new generic system based on an ARM has been developed for bioelectronic
recording of medical data. This project is about developing the user interface and
control software including a touch screen, patient database and real time display. The
system is currently implemented with the Keil development tools but ideally should be
ported to LPCXpresso as the project is intended to be made available for open source
use on GitHub.
6. **Modeling and Image processing 4D MRI flow data to characterize heart disease**
   This is a new project with the Charles Perkins Centre to look at improved methods to process and understand 4D (time series) cardiac MRI data. This technique uses tailored pulse sequences and compressed sensing so a background or keen interest in these areas is desired. Modeling will include fluid dynamics, mechanics of the cardiac muscle and electrical properties associated with heart disease.

7. **Near infra red and Electrical impedance spectroscopy for in-vivo assessment of the post-ischemic cardiac tissue.**
   This project aims to use in-vivo animal data collected with cardiologists at Westmead hospital to assess if the changes in the electrical impedance or NIR frequency response of tissues can be used to identify different tissue types and tissue changes associated with heart disease. It will involve instrumentation, animal measurements and data/statistical processing.

8. **Functional Electrical Stimulation assisted by EMG feedback**
   This is a new project with Exercise and Sports Sciences at the Lidcombe/Cumberland campus. The project involves building a new functional electrical stimulation circuit based on new components, in particular new high voltage CMOS switches. A new control system will be built, based on Arduino or another suitable platform and incorporated with EMG to provide closed loop feedback to the stimulator.

9. **Electronic device development for subcutaneous NIR measurements**
   This is a continuation of a project funded by the Bill and Melinda Gates foundation to develop a low cost device to measure malnutrition in the developing world. The student will be required to modify the circuit design and test the device on models and may be required to assist measurements of newborns at RPA Hospital.

10. **Subdivided electrodes to improve defibrillators and physiological measurements**
    Current defibrillators and monitors (EEG, ECG etc) are limited by variations in contact impedance. In this project the student will be required to develop a range of electrodes that will allow contact impedance monitoring and test their ability to reduce this problem with electronic feedback.

11. **Magnetic Resonance Electrical Impedance Tomography**
    MREIT is a new medical imaging method that allows the electrical conductivity of tissue to be directly measured in the MR scanner. It has high potential for implant design, monitors and understanding of electrical behavior in the body such as neural and cardiac function or wound healing. In this project the student will use a software tool developed by collaborators in Korea to simulate a range of improvements and scenarios in MREIT. It requires a good background in electromagnetics.
12. **Noncontact measurements of heart rate and respiration**
This project is motivated by an urgent need of a large biomedical company in Sydney. The aim is to review novel methods of physiological measurement. The student will be required to demonstrate feasibility of the device via simulation or prototype setup.

**Supervisors:** Dr. Alistair McEwan and Paul Carter, Cochlear  
**Location:** EIE and Cochlear

13. **Development of an electrical impedance phantom for a cochlea electrode array**
This project requires a highly motivated student interested in physiological measurements and development of medical devices. The ideal student would have a strong interest in electrical circuits and in developing a practical experiment. The aim is to develop a physical spectroscopic model of the impedance presented by tissue and fluid in the cochlea using gel and organic conductor filaments. The proportions will be based on anatomy and published impedance data from relevant papers. The student will be required to learn and understand the setup of stimulation and measurement parameters for the impedance analyzer and the cochlea array. The project could be extended in developing custom hardware and assisting with invivo testing of the device.

14. **Modelling and simulation of electrical impedance based imaging of a cochlea electrode array.**
This project requires strong computational modelling skills, ideally with previous experience of FEM modelling in Matlab, Ansys or Comsol. The aim is to develop a 3D FEM model of the impedance distribution of the tissue surrounding the cochlea to determine the feasibility of impedance imaging here. This is likely to be a highly computationally demanding task so experience or interest in writing efficient simulations, use of high performance computing and optimized inverse methods would be an advantage. The project could be extended to include MRI based data and anisotropy.

15. **Joint projects with the Brian and Mind Research Institute**
The medical imaging physics and biomodelling group, located at the Brain and Mind Research Institute, develops novel instrumentation and computational methods for imaging the distribution and kinetics of radio-pharmaceuticals in the body. These techniques are used by collaborators for the laboratory testing of new drugs and imaging probes in various brain disorders, including neuro-degenerative diseases, and in cancer. Students in our lab use a wide variety of research tools, from Monte Carlo simulation, modelling, programming, sensor development and signal processing through to experiments with phantoms, animals and human subjects. There are opportunities for biomedical engineering students to undertake final year projects in: (1) Motion tracking and correction techniques for animal and human imaging studies, (2) Simulation, design and evaluation of novel PET and SPECT imaging systems, (3) Development and validation of image reconstruction and related algorithms for improving the accuracy of small animal PET and SPECT measurements.