QMB Medical Devices and Technology Abstracts

M1: Implantable devices: lessons in taking devices to the clinic

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Medical bionics devices record from and/or electrically stimulate excitable tissue in order to improve health outcomes. Since the introduction of the first heart pacemaker in the 1950s, there have been a number of bionic devices approved for clinical use, resulting in a dramatic impact on the quality of life of millions of people around the world. These technologies depend on fundamental biomedical engineering principles and a thorough understanding of the anatomy and physiology of the target neural population. This talk will provide an overview of the design principles of bionic devices, using examples from our research.

Five devices currently dominate neural stimulation from a clinical perspective: cochlear implants to treat profound hearing loss; spinal cord stimulation to treat severe back pain; vagus nerve stimulation to treat epilepsy and depression; deep brain stimulation to alleviate the motor disorders associated with Parkinson's disease and essential tremor; and sacral root stimulation for bladder control in patients with spinal cord injury.

Significantly, there are a large number of devices currently undergoing development, fuelling expectations that this field will undergo major expansion over the next decade. One example is "bioelectronic medicine" designed to treat a broad range of diseases, from arthritis to Crohn's disease using excitatory or inhibitory neuromodulation techniques.

These initiatives call for significant multidisciplinary technical and commercial collaboration including clinical, engineering and scientific expertise working with IP management, regulatory, clinical trials, commercialisation and manufacturing expertise.

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M2: A transcutaneous energy transfer method for deeply implanted miniaturised biomedical devices

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The development of miniaturised biomedical implants, such as neural stimulators and leadless pacemakers is constrained by the lack of a reliable power source. Primary batteries are either large or operate for short durations preventing their use in miniaturised implants. Traditional wireless inductive charging is also challenging as the small size of the device and deep implantation lead to high field strengths and the danger of tissue heating. Further, the receiver coil in inductive systems takes up significant room in the implant. This research proposes a new transcutaneous energy transfer (TET) method to deliver power to miniaturised deeply implanted biomedical devices. This technology uses a pair of electrodes placed on either side of the body to generate an internal varying electric field. The electric field then gives rise to current flow, which will create an electromotive force (voltage) on a pair of receiving electrodes. Unlike the current TET systems, this method allows for the body of the implanted device to act as part of the receiving circuitry, eliminating the need for a pickup coil. Analytical circuit models leading to a two-port network, together with COMSOL simulation models are created to give an insight into the working principle of the technology. Experimental results show a good match with the theoretical work. They indicate that 10mW of power can be transferred at 75mm away from each transmitting electrode. In addition, simulation results have confirmed that the power supply produces less than 2W/kg of specific absorption rate (SAR), which meets the requirements of electromagnetic safety standards such as IEEE C95.1.

M3: A Novel Passive Stoma Output Recycling Device for Managing Ileostomies: Design and Feasibility Study

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Management of rectal cancer often necessitates formation of a temporary loop ileostomy (TLI) and rectal anastomosis. As a result, many patients suffer from high TLI outputs, with ~15% readmitted for fluid replacement[1, 2], which is costly. Recycling TLI output back into the downstream bowel is a possible solution, once the rectal anastomosis has healed. However, routine clinical application is currently limited by the lack of a simple, acceptable method. We therefore aimed to develop a novel stoma output recycling device.

A first-in-human feasibility trial has been commenced. Patients aged ≥18 years, bearing a TLI and with a proven negative anastomotic contrast study are being recruited. The novel device is a passive recycling system within a stoma appliance. Technical assessment, tolerability and patient safety were measured using a standardised proforma. Device iterations were regularly introduced throughout the trial.

In total, 11 patients were screened, of which 4 were successfully recruited, for a sum of 45 individual device trials across 7 device iterations. Technical feasibility of output recycling was achieved after 6 iterations. The two most recent iterations showed successful recycling with return of bowel function, and small volume leakage (~4-5 tsp/hr). Qualitative analysis revealed no discomfort on device insertion and only mild discomfort during its use (median Likert scores of 10 and 8 respectively; 0 being severe discomfort and 10 being nil).

In conclusion, our novel device was well tolerated and accepted by patients, and could help to reduce the complications of TLI in future. Further validation of technical feasibility and device refinement is currently in progress.

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M4: Safety of a Wireless Power Transfer System for Powering Heart Pumps

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Implantable heart pumps such as ventricular assist devices (VADs) are commonly used in patients with late stage heart failure as a bridge-to-transplant device until a suitable donor is available. Recently, with technological advancements, VADs are used as a therapeutic device for patients in early stages of heart disease. No implantable battery is capable of meeting the continuous, high power consumption requirements of a VAD. All commercially available VADs rely on a percutaneous driveline to transfer power from an external battery pack. However, the main cause of adverse events for VAD patients is infection around the driveline wound.

A transcutaneous energy transfer (TET) system consists of an external coil coupled inductively to an implanted receiving coil and delivers power wirelessly across the skin, eliminating the risks associated with a driveline. For the safety of the patient, the implant surface temperature and the rate of energy absorption by tissue when exposed to the radio frequency electromagnetic field generated by the coils must be within acceptable levels.

As excessive heat can lead to irreversible tissue damage, the International Organization for Standardization (ISO) sets a maximum implant surface temperature to be no greater than 39 °C. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) limits the maximum specific absorption rate (SAR) to be 2 W/kg averaged over 10 g of tissue. *In silico* and *in vivo* evaluation showed that the proposed TET system is within acceptable limits for patient use, with a peak SAR of 0.118 W/kg over 10 g of tissue and a maximum implant surface temperature of 38.2 °C.

M5: Package-integrated MEMs sensors for long-term implantation: Use of nanoscale profilometry to verify performance

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The development of sensors for long-term implantable devices is a seemingly simply task given the availability of high-performing transducers from automotive, aerospace and consumer electronic sources - in particular mass-produced MEMs. However, these sensors fail quickly *in vivo* and must be protected from the host, even for short-term application. For long-term implantation the protection requirement increases and developers employ hermetic 'packaging' to isolate transducers and associated electronics from the body. However, the resulting sensor often has a performance that is as dependant on the package as the original transducer. Given the importance of packaging on sensor performance, we propose that designing medical sensors for long-term implantation can benefit from a consideration of the complete sensor – transducer, electronics, and package – from inception.

Accordingly, our group is in the process of designing, modelling and verifying the performance of a MEMs sensor that has the transduction element directly integrated into the hermetic package. The role of long-term mechanical changes (e.g. stress relaxation) in signal drift in MEMS transducers is well known, but the means to assess them are test specific and difficult to implement.[1] We have therefore developed custom techniques to verify our sensor performance independent of other sources of drift (e.g. electronic, thermal) using nanoscale profilometry. This technique allows us to quantify minute changes in the sensor shape that can be used to infer performance characteristics. In the current example, we have used profilometry before and after cyclic testing to verify that the expected drift from mechanical sources is acceptably low.

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M6: Design and Manufacturing of Alginate-Polyacrylamide Hydrogel Matrix Composites as Minimally Invasive Cartilage Implants

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The advent of orthopaedic prostheses and their widespread applications have helped millions of patients worldwide to be relieved from pain and gain their mobility. However, they are still not suitable for young or middle-aged patients suffering from localised cartilage damage, due to the limited life span of these load-bearing medical devices. All available remedies for those patients are temporary and some of them might result in regeneration of tissues with different properties to the existing one, and hence limited functionality and durability. Therefore, an alternative way should be investigated to prevent further tissue degeneration through replacing damaged regions of the tissue and preserving the remaining healthy portion.

An alternative synthetic cartilage replacement is investigated and developed in this research for the young patients with localised damaged articular cartilage, to prevent further tissue degeneration by removing the articular cartilage lesions, and replacing them with the minimally-invasive implant, hence preserving the healthy tissue, and prolonging the tissue functionality. Moreover, the implant could greatly contribute in postponing the joint replacement, if not totally eliminating the need for such surgical operation altogether. Due to its minimally-invasive feature, it is expected that the implantation could be performed on the patient's joints multiple times to replace damaged tissues until joint arthroplasty becomes inevitable.

M7: Cardiovascular Health Engineering: from Wearable MINDS to MISSION 2024

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M8: A review of PWV-based cuffless blood pressure measurement

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Blood pressure (BP) measurement is a well-known clinical method to monitor cardiovascular function, and it is also a strong predictor of death and cardiovascular disease. Currently, the cuff-based sphygmomanometer is the most popular form for BP monitoring in the home setting, but it cannot measure BP changes beat-to-beat. Additionally, the cuff structure makes it difficult to be designed as a wearable device for ambulatory monitoring. This review introduces several promising approaches for BP monitoring and provides useful information for further development .

In recent years, a strong relationship between pulse wave velocity (PWV)/pulse transit time (PTT)/pulse arrival time (PAT) and BP changes has been indicated. Researchers express this relationship using mathematical models to estimate BP. The commonest technique to detect PTT is the ECG-PPG (electrocardiogram-photoplethysmography) method which calculates the time delay between ECG waveform at a proximal point and PPG waveform at a distal site (e.g. finger, ear, and toe). To evaluate their results, this review compares available literature for two aspects: statistical analysis and clinical protocols.

The common issues were that existing models are composed of subject-dependent parameters and required intermittent re-calibration with traditional sphygmomanometers. In other words, the information from pulse timing is inadequate for BP estimation. To overcome this, other parameters can be incorporated into the model, such as heart rate and diameter changes of artery. Several researchers have achieved considerable improvements using this method and it is believed that these techniques may become feasible for continuous BP monitoring.

M9: Site specific bone mineral density assessment using MARS spectral photon-counting imaging

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Bone mineral density (BMD) is known to decrease naturally with age and diseases such as osteoarthritis (OA), which affects both bone and cartilage in the joint.[1] Dual-energy X-ray absorptiometry (DXA) is used clinically to measure BMD but is limited to a low resolution, two dimensional areal image of bone and lacks information on bone structure and nearby soft tissue.[2] The purpose of this study was to investigate utilization of MARS spectral photon-counting imaging for site-specific bone health assessment and its comparison to the current reference standard of DXA. Four femoral necks (female: age 42-87) were analysed to assess BMD changes with increasing age. Six lateral tibia plateaus (four female: age 61-69, two male: age 58) were analysed to assess BMD changes observed with mid (outer and middle region) and early (inner region) OA states. All specimens were scanned with clinical DXA and MARS imaging.[3] MARS reconstructed images underwent material decomposition to provide quantitative information of hydroxyapatite bone component for analysis of BMD.

Femoral neck age difference BMD measurements from DXA were proportionate to MARS volumetric BMD measurements with both modalities showing the expected trend of decreasing BMD with increasing age. MARS volumetric BMD of the outer and middle regions of the lateral tibia plateau (mid OA) have a similar trend to DXA BMD whereas the inner region (early OA) MARS volumetric BMD measurements were below the DXA BMD measurement trend. This may be due to a larger proportion of trabecular bone in this region. Spearman Rho correlation coefficient between MARS imaging and DXA for the femoral neck (r=0.8) and tibia plateau (r=0.72) were large. In conclusion, MARS imaging can provide site-specific BMD measurements comparable to current bone densitometry techniques to assess bone health related to age and disease as well as image bone structure and nearby soft tissue.

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M10: Lasers, Hot Glue, and Legos: Designing a Device to Predict Myopia in Children

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Myopia (short-sightedness) is a growing concern for our current and next generation[1,2]. Excess strain on eyes, starting in children, has led to a dramatic increase in vision problems for adults. Sixty years ago, 10-20% of the Chinese population was short-sighted, whereas today, up to 90% of teenagers and young adults demonstrate myopia[2]. In Europe and the United States, the rate of myopia has doubled in the last half century[1,2]. Corrections include glasses, contacts, and surgery. However, these are reactive measures, not preventative: continued strain could lead to retinal detachment, cataracts, glaucoma, and potentially blindness[2]. Currently, the elongation of the eye can only be deduced for adults; there is no existing method to predict the onset of myopia in the early stages of life, when it is most critical.

Our company, TOKU Eyes – a start-up incubated within the University of Auckland - has set out to create a new, innovative method to image the axial length of the eye, both in children and adults. The preliminary prototype is designed to utilise the benefits of laser imaging, ensuring the measurements are both non-invasive and non-contact, in order to obtain the relevant biometric data. Our apparatus utilises an 808 nm (IR) laser, tested with 0.3mW to 0.6mW, and imaged with a scientific IR camera. Experiments have been completed primarily on porcine eyes. Specialized Python programs calculate the axial length in gold standard MRI images, then use these in a comparison with our device to deduce accuracy. Additional tests were done to ensure repeatability and reproducibility, setting the framework for a reliable product. Our device image has a distance measurement with a mean of 68.1329 pixels (standard deviation of 0.5141). This will be correlated with the MRI, with an accuracy of 0.3516 mm. The correlation is non-linear, and is still being investigated.

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M11: Monitoring masticatory muscle activity by a smart-phone assisted wearable device

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Little is known about the pattern of masticatory muscle activity (MMA) outside laboratory conditions. The first aim of this project was to validate a wireless smartphone-assisted electromyography (EMG) device in 12 volunteers, using standard wired electromyography equipment as reference standard. The findings indicated that the EMG device reliably detected MMA. Indeed, the intra-class correlation coefficients for the amplitude and the duration of masseter muscle contraction episodes (MMCEs) detected by the wireless and the wired equipment ranged from 0.94–1.00 to 0.82–1.00, respectively. Most MMCEs detected during free living conditions were of low amplitude (< 10% maximum voluntary contraction) and short duration (< 10 s). Attempts to record MMA over several days had to be abandoned due to skin irritation and problems of the gel-based Ag/AgCl electrodes.

The second aim was to optimise electrode characteristics to permit long-term EMG recordings. Five different electrode materials and 3 interelectrode distances (IEDs) were tested in 10 volunteers, as they performed standardized oral tasks in the laboratory. Based on an electrode performance index (EPI) calculated for the different oral tasks, no significant differences were found between different IEDs. However, significant differences were found in the electrode materials tested, with gel-free graphene coated silver electrodes having the highest EPI for all oral tasks investigated.

The third aim was to investigate the relationship between masticatory muscle EMG and physical activity (PA) during unrestrained free-living conditions. Fifty-five volunteers simultaneously wore the wearable EMG device and a wrist based accelerometer for two separate days. Mixed model analysis showed a negative association between the number of MMCEs and moderate to vigorous physical activity (MVPA), indicating that individuals with low levels of MVPA may be at risk of tooth clenching.

The findings provide new insights on our understanding of MMA, as it naturally occurs during unrestrained conditions.

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M12: A novel biofeedback device to prevent and treat pelvic floor muscle disorders in women.

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The prevalence of Pelvic Floor Muscle (PFM) disorders women is high, affecting millions of women all over the world. These disorders often manifest as Urinary Incontinence (UI) and Pelvic Organ Prolapse (POP) which can be a result of PFM weakness for a variety of reasons. To prevent and treat these disorders it is well-recognised that improving PFM function through specific exercises (contractions) is effective [1]. However, these exercises are difficult to explain, difficult to monitor, and there is little (to no) feedback for how the muscle function and strength is improving throughout training. We have developed a novel device (FemFit®) designed to enable women to manage their own PFM health. Eight sensors, encapsulated in biocompatible silicon, form a pressure sensor array to record pressures within the vaginal cavity, generated by the PFM [2]. A woman can insert this device before they undertake their PFM exercises. As she contracts her PFM the pressure sensors are activated and feedback is immediately provided via a tablet or smart phone application.

The FemFit® is the only wearable technology that can accurately measure the three pressure zones within the vagina. Identifying whether pressure is generated by the abdominal muscles or the PFM is crucial when educating women on how to contract their PFM effectively. Alternate applications of the FemFit® are being explored through ongoing research. Its utility is such that the FemFit® could be used in a clinical setting to assist with POP diagnosis and surgery, or perhaps as a tool to inform women at the gym if they are helping or harming their PFM, particularly when returning to exercise post childbirth.

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M13: Buzznudge: Augmenting Stroke Rehabilitation Through Haptic Nudging

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Eighty percent of people with stroke experience difficulty moving their upper limb (UL)[1]. Larger volumes of rehabilitation and physical activity after stroke promote improved outcomes[2]. Given the limited amount of spontaneous UL movement following stroke and the challenges associated with increasing the dose of UL rehabilitation there is a pressing need to develop technologies to augment rehabilitation[3]. The aim of this study was to determine whether haptic nudging of UL movement via a wrist-worn wearable device would promote UL movement during stroke rehabilitation.

A multiple-period randomised crossover design was used to measure the association of UL movement with the occurrence of haptic nudge reminders to move the affected UL in eighteen people with stroke undertaking inpatient rehabilitation. UL movement was observed and classified using a movement taxonomy across 72 one-minute observation periods from 07:00 h to 19:00 h on a single weekday. On 36 occasions a Nudge to move the affected UL was provided just prior to the observation period and on the other 36 occasions No Nudge was given. The timing of the nudge was randomised.

Odds ratios (OR = 1.47, 95% CI [1.29, 1.65]) indicated that the odds of moving the affected upper limb was 47% higher following a Nudge than No Nudge. Secondary analysis revealed that the odds ratio (OR = 2.06, 95% CI [1.67-2.54]) of moving the affected upper limb independently was 106% higher following a Nudge. Yet, the odds of a bilateral movement (OR = 1.14, 95% CI [1.06-1.31]) was just 16% higher.

Haptic nudging represents a potentially powerful stroke rehabilitation tool which increases the amount of affected UL movement during the rehabilitation day. In a comprehensive wearable technology haptic nudging could be combined with other behaviour change and persuasive strategies to further promote movement.

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M14: Enhancement of a two-wheeled robotic wheelchair's battery life through a novel stability mechanism

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Two-wheeled robotic wheelchairs are good alternatives for Four-wheeled robotic wheelchairs, as they have better manoeuvrability. However, they are not statically stable and a controller needs to be deployed to keep system stable. In most conventional two-wheeled robotic wheelchairs, the wheels motor should provide required power for reaching the desired velocity and keeping the stability of the system simultaneously which leads to high power consumption. To resolve this problem, a novel approach is proposed to achieve both tasks where the wheels motor supply required power to reach the desired velocity while the stability of the wheelchair is maintained by a movable mechanism added to the wheelchair. The sliding mode controller which is robust against disturbances are developed to control the velocity and stability of the wheelchair. Simulation results show that the proposed approach require less torque and power than conventional one which enhance the battery life of wheelchair.

M15: Reducing motion artefacts in *in vivo* MARS imaging

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Ex-vivo imaging of excised atherosclerotic plaques has already demonstrated that MARS imaging can image structural features that are thought to be indicators of vulnerability. In atherosclerosis, vulnerable plaques can rupture and may cause strokes and cardiovascular events. *In vivo* MARS imaging of plaques has the potential to improve patient outcomes. However, the image quality will be affected by motion artefacts if left uncorrected. This work outlines an image domain-based motion correction technique for alleviating motion artefacts in reconstructed images from the MARS scanner. The method successfully corrects motion artefacts during in vivo animal imaging and is translatable to human imaging.

An anaesthetised mouse was imaged using a MARS small-bore scanner. The diaphragm edge of the mouse was chosen as a moving reference. A tracking window followed the reference edge over the projection data. The respiration signal of the mouse was obtained by tracing the mean intensity in the tracking window throughout all acquired projection data. Each projection image was then labelled and sorted into a set of respiration classes based on the phase component of the respiration signal [1, 2]. Each respiration class was reconstructed separately.

The improvement in identification and sharper definition of the moving structures in reconstructed volumes highlights the effective suppression of motion artefacts. The diaphragmatic edge was perceived to be sharper in the expiration class compared to the inspiration class and un-corrected volumes.

In summary, a motion correction algorithm has been developed to improve the image quality and diagnosis from *in vivo* imaging. The algorithm tracks a region containing periodic moving structures. While demonstrated on a mouse diaphragm, there is no restriction on which structures can be tracked and therefore corrected. In future studies, we aim to apply this technique to perform *in situ* imaging of carotid arteries to characterise unstable plaques.

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M16: Comparison of Antimicrobial Activity of Silver, Graphene and Copper Nanoparticles as Filler to PDMS Substrate

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Skin attached sensor is a type of medical device which is mounted to human skin to acquire signals. For example, ECG sensor is attached to several spots on skin to measure electric signal generated by heart. Some sensors for healthcare monitoring like ECG sensors require long term contact between sensor and skin. It is desired that the surface of sensor has ability to prevent bacteria growth in order to avoid infection through skin. Polydimethylsiloxane (PDMS) is a type of silicone elastomer widely used for fabricating skin sensors for various purposes [1]. PDMS can be doped with conductive particles to conduct electric current. Past research shows that conductive particles such as silver nanoparticles (Ag), copper nanoparticles (Cu) and graphene nanoparticles are able to prevent bacteria growth [2]–[4]. The strength of antimicrobial properties for these material as fillers for PDMS substrates had not been compared.

This research compares the antimicrobial activity of these nanoparticles in both wet and dry environment. Experiment result indicates that in a dry environment, silver nanoparticle is as effective as graphene on inhibiting growth of bacteria. Copper nanoparticle is weaker than the two; In a wet environment, copper becomes the strongest antimicrobial agent, following by graphene; silver nanoparticle is least effective when compared with the other two.

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M17: Developing implantable light sources for optogenetics

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Optogenetics is a developing field where visible light is used to stimulate or inhibit activity of neurons and nerves that have been modified to express light sensitive ion channels called opsins. It has been useful in neuroscience research to uncover how particular brain pathways function and has shown promise as a potential treatment for neurological disorders such as Parkinson's.

A light source must deliver enough energy to activate opsins. Depending on the location of the targeted cells, light may need to propagate through brain or nerve tissue before interacting with opsins. Absorption and scattering of photons by tissue reduces the amount of light reaching opsins.

Benchtop LED and laser diode sources can easily deliver sufficient optical power but are limited in the duration and type of experiments that can be performed as the animal must be tethered to the source for the duration. Implantable light sources will enable long term optogenetic animal studies but in order to be viable they must deliver enough light to activate opsins without increasing the temperature at the implant site. LEDs offer the best combination of optical power and low heat production for implantable sources.

Using Monte Carlo ray tracing simulations, implantable light sources can be optimised to maximise optical power delivery while minimising electrical power requirements by varying the geometry of the LED, packaging, and the intensity of emitted light. Modelling shows that, for a given optical intensity, a larger volume of tissue can be illuminated with an LED compared to a fibre optic cable.

M18: A novel method for continuous systolic blood pressure monitoring using convolutional neural network

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Objective: Demonstrate the feasibility of deep learning technique, convolutional neural network (CNN), to estimate the systolic blood pressure (SBP) using electrocardiogram (ECG) and photoplethysmography (PPG) signals. Background: Blood pressure (BP) is inversely related to Pulse transit time (PTT). PTT is related to the time delay between the R-wave of ECG and specific points of PPG waveforms. Although PTT-based techniques are promising, PTT alone cannot fully represent BP, as it is highly influenced by physiological and neurological factors. To increase the accuracy, a variety of additional cardiovascular features can be extracted from time or frequency domain representations of ECG and PPG signals to train the BP model. However, mining and processing this data are challenging. Method: A total of 20 patients with available ECG, PPG and SBP data were selected from the Medical Information Mart for Intensive Care (MIMIC III) waveform dataset. 15 cardiac cycles were extracted for each patient, centred on R-peaks and sampled at 125 Hz. Data were randomly assigned to training (70%) and testing (30%) sets. A CNN-based model was developed with four convolutional layers, one fully connected layer, and one regression layer. To reduce overfitting, a dropout layer that performs regularization with a dropout ratio of 20% was used before the fully connected layer. CNN input was PPG and ECG time series. Results: The accuracy of model were calculated by dividing the number of correctly predicted SBP to actual SBP. The results showed a high test accuracy of 87.42% and root mean square error (RMSE) of 6.57 mmHg which is within an acceptable error margin that set by Association for the Advancement of Medical Instrumentation (AAMI).

M19: Vibration Analysis of Piezoelectric Cylindrical Transducers with circumferential Step-Thickness

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In many biomedical devices, ultrasound transducers have numerous applications ranging from medical diagnostics, atomizers, humidifiers, drug delivery devices, etc. Hence, it is of particular importance to enhance the performance of these transducers which requires investigations into their vibration and acoustic characteristics.

To this aim, in this research, we investigate the vibration of circumferentially stepped thickness piezoelectric cylindrical transducers. It is intended to evaluate the effect of these steps on the vibration mode shape as well as stress concentration for the safe performance of the transducer. To do so, we consider two types of circumferentially stepped cylindrical shells having two and three steps. ANSYS software as a strong FEM tool is employed for analysis.

The obtained results prove that the vibration is localized within the thin, stepped regions. It is revealed that this method can be carefully implemented for mode shape control and stimulating certain intended mode shapes with various circumferential wave numbers.

M20: Commercialising research: a clinical scientist's experience

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M21: MARS imaging of microfractures with targeted nanoparticles for early risk assessment of osteolysis

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Joint replacement surgery has become one of the most successful interventions achieved in modern medicine, having huge impact on the quality of life for patients suffering joint diseases. However, an immunological response or change in the bone's structural load following implant procedures commonly induces osteolysis. Osteolysis refers to a pathological process that results in bone loss due to active reabsorption of bone matrix by osteoclasts. Although the osteolytic process itself is asymptomatic, implant loosening and subsequent bone fracture eventuates. Limitations of current medical imaging means diagnosis of osteolysis typically takes 6-12 months after first triggered, due to metal-induced artefacts distorting imaging of the bone-metal interface. MARS imaging may provide a means to solve this clinical problem by unravelling the mechanism involved in osteolysis and aiding in identifying diagnostic biomarkers, such as microdamage at the bone-metal interface.

The present study examined MARS imaging of bone microdamage using targeted Hafnium nanoparticles (HfNPs). Two rat specimens were anaesthetised prior to receiving scalpel-induced bone microdamage in one hind limb. Targeted or non-targeted HfNPs were injected intramuscularly. Five hours post-procedure, the animals were euthanised and then scanned.

The key findings in our proof of concept study were: (1) MARS imaging materially separated HfNPs and bone-like material in a whole rat specimen; (2) HfNPs were quantified; the total amount (mg) was greater in the injured limb compared to the healthy limb, and for targeted NPs compared to non-targeted; (3) HfNP concentration profile along the limb may indicate the nature and extent of the microdamage.

MARS imaging captures the bone-metal interface at high spatial resolution and can identify and quantify nanoparticles targeted to potential diagnostic biomarkers. In the future, MARS imaging used in conjunction with targeted nanoparticles will allow diagnosis of osteolysis months before bone matrix is lost.

M22: Validation of high-resolution electrogastrography against gastric emptying scintigraphy as predictor of symptoms of functional gastrointestinal disorder

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Functional gastrointestinal disorders (FGIDs) afflict one-in-three New Zealanders. However, effective diagnosis of FGIDs remains difficult, relying on insensitive motility tests, or non-specific subjective symptom questionnaires. One contributing factor proposed to underlie some FGIDs has been spatial gastric myoelectrical dysrhythmias (1). These have recently been recorded in experimental studies using high-resolution electrogastrography (HR-EGG) (2).

We aim to develop a clinically useful workflow for HR-EGG as a diagnostic aid for FGIDs, to be compared against gastric emptying scintigraphy for diagnosing gastric dysfunction.

A novel HR-EGG recording system was developed to evaluate gastric electrical dysrhythmias. Patients are given a wearable electrode array, an acquisition box and a symptom-logging app for correlating symptoms with electrophysiology. Propagation patterns from HR-EGG are compared to a symptom and meal timeline, and gastric emptying time course from the simultaneous scintigraphy study.

Current results have focused on development of the new clinical device. An electrode array was developed to wear on the patients' abdomen for up to 24 hours and tolerance was excellent as tested. Benchtop testing validated device performance across a reference physiological frequency range. Prototype production has now begun, and validation will be performed against gastric emptying scintigraphy. Percentage of abnormal slow wave direction will be correlated with symptom severity.

Ergonomic HR-EGG could fit smoothly into clinical practice to provide a more certain diagnosis for FGID patients, with or without abnormal gastric emptying, and without relying on symptoms alone. The sensitivity and specificity of the test awaits confirmation. Improved knowledge of GI pathophysiology from this novel technology will hopefully also allow for improved future treatments.

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M23: Development and Evaluation of Dry-Contact, Wearable, Biopotential Sensors

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The driving force behind ongoing advancements in dry-contact biopotential sensor development (particularly for EEG measurement systems), is the user-comfort, reduced set-up time and sustained period of use that can potentially be exhibited in wearable devices. However, competing with the signal quality of traditional wet-contact biopotential sensors can be a challenging task. Review of the literature suggests in order to procure the quality of signals measured, the following noise sources need to be significantly reduced in dry-contact EEG measurements: Environmental noise - produced by mains interference and pink noise (1/f noise) or physiological noise - produced by eye movement, cardiovascular activity and body movement causing displacement of electrodes. Techniques to reduce this unwanted noise in dry-contact systems includes the following: Enhanced common mode rejection of an adapted driven right leg circuit compared to a reference ear electrode design (reduce mains interference), a chopper circuit design (reduce pink noise) and the use of active electrodes compared to wire connected electrodes (reduce body movement). An Investigation into design and processing techniques to remove effects of the unknown impedance present at the electrode-tissue interface was also undertaken. Full simulations of design improvements investigated above were achieved using Linear Technologies SPICE simulation software, LTspice. Real life EEG data (as text files) were acquired online from the Department of Epileptology, University of Bonn and used in these simulations. All processing and analysis of results obtained in the simulations then took place in MATLAB.

M24: Investigation into the Mechanisms of UV Transmission to Follicular Stem Cells and Implications for Melanoma Development

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Melanoma is the deadliest type of skin cancer with its prevalence on the rise. Recently, melanocyte stem cells in hair follicles have been identified as a possible origin of melanoma upon exposure to ultraviolet radiation (UVR) through skin. It is hypothesized that colourless vellus hair (predominant in childhood) can serve as an alternative pathway in transmitting these ultraviolet (UV) photons to the stem cells. To investigate this, we have used the CRAIC microspectrophotometer to investigate the optical properties of 'vellus-like' hairs and terminal hairs of different colours using UV-VIS-NIR light sources. It was found that the average attenuation coefficient of 'vellus-like' hair is significantly lower than that of terminal hair in the UVA ($p < 0.0001$) and UVB ($p < 0.001$) wavelength ranges. Next, the optical properties of hairs are applied to simulations for examining their influence on UV transmission into the skin. The results show that the presence of vellus hair would increase the solar UV transmission to the melanocyte stem cell layer significantly.

Our research provides new insights into the mechanism of melanoma development: Children with high sun exposure tend to have a greater risk of developing melanoma in later life as their follicular stem cells might have received a greater amount of UV transmitted via vellus hair. This research may lead to the improvement of melanoma prevention, e.g. improvement of the efficacy of sunscreens.

M25: Designing a device to monitor for early myopia in children

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The rise in myopia (short-sightedness) in children is raising concerns in our global health sector with an estimated 22.9% of the world population [1,2], making early preventative measures crucial. The prerequisite of slowing down the rate of myopia progression in children is to reliably measure it over time. Currently, clinical devices employ interferometric techniques, which cannot address the paediatric population.

Our company, TOKU Eyes, is currently developing a device aiming to provide accurate and convenient imaging of the eye in children, particularly in rural regions. Our working prototype is a non-contact, non-invasive optical device that can perform basic biometry. Proof of concept animal trials have successfully been completed with comparison of our current device to MRI.

Current work focuses on translating this technology into the clinical environment. The 510(k) pathway will be taken, where we match the parameters of a predicate device such as the Lenstar LS 900. In order to qualify, our device should achieve a measurement resolution of 0.01mm, a reproducibility standard deviation of 0.025mm, a physical measuring time of 0.5s, and a safe, reliable optical power of <0.6 mW using a class I infrared laser. The process involves optimising the device by accurately conducting measurements of the power, refining the usability of the device, as well as ensuring repeatability and reliability. Our design aims to address these FDA requirements for medical devices, such as risk analysis and quality management.

The goal is for the device to be operated on paediatric patients in a comfortable environment, while providing highly accurate and rapid measurements. The implementation of our device will be valuable in aiding early preventative measures for child myopia and also the planning of cataract surgery.

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M26: An investigation into improving the CPAP for the Obstructive Sleep Apnea treatment

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Obstructive sleep apnea (OSA) is considered a worldwide public health problem. Current OSA treatment include the (CPAP), and considered as the primary choice to manage OSA patients. However, the CPAP has many drawbacks. For example, it may be associated with upper airway (UAW) congestion, and significant dryness. the project aims to quantify humidification within (UAW) during application of CPAP. Also, to determine the impact of applying pressure oscillation (PO) on humidification parameters of the UAW. To address this part, an *ex vivo* experimental setup was developed to quantify the air humidification at different CPAP operating conditions. While the *in vivo* tests were conduct using a proper clinical trial.

Results from ex vivo studies have confirmed that at normal breathing, the reconditioning of inhaled tidal volume may lead to a fluid depletion within the depth of airway surface liquid that equal to 2.17 $\mu L/cm^2$.min.However, applying the CPAP at different pressure of (5,10 and 20 cmH_2O may affect this value, significantly. Results of ex vivo studies have confirmed that a reduction percentage within tracheal Fluid depletion can be 38.4 % up to 75.8 %. The highest reduction percentages were associated with applying CPAP at 20 cmH_2O. Applying the PO at frequencies of (5, 20 and 30) Hz, results show a remarkable improvement within the tracheal fluid depletion at any pressure value of CPAP. However, the highest improvement percentage of 78.8 % was achieved at applying PO at 30 Hz, in conjunction with the CPAP at 5 cmH_2O.

Results of clinical trial show that applying full session of CPAP, saliva samples collected from participants have witnessed a drastic reduction in their salivary flow rate, which was already considered as low. Reduction percentage values were ranged from 5.81 % to 70.15 %. The highest decreasing percentages within the salivary flow rates were found with participants of BMI higher than 34.4 kg/m^2. However, a major improvement in the salivary flow rate recorded from participants after CPAP and PO treatment sessions. Improvement percentages are in the range of 0.49 to 1.39 mL/min, representing an increasing percentage between 9.4 % up to 129 %. The highest improvement was recorded within the salivary flow rate of the participants with a BMI of 29.9 kg/m^2.

Results may confirm the efficacy of applying the PO in conjunction with the CPAP to improve dryness symptoms that mainly associate with the use of the CPAP.

M27: Creating toolboxes for 4D cell culture systems

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The conventional approach to cell culture uses 2D surfaces to attach and grow cells on tissue culture polystyrene (TCPS). These systems are used to examine the fundamental biological pathways of disease, evaluate the cytotoxicity of biomaterials, explore biochemical pathways and model wound healing (to name just a few). While these systems are central to much of our current research paradigm, it is well established that they fail to reproduce many of the cell-cell signalling and external cues experienced by cells in tissue.[1]

There is an increasing movement internationally towards replacing, reducing and refining animal testing including the EU Directive on the protection of animals used for scientific purposes (EU Directive 2010/63/EU). It is clear that there is and will continue to be increasing demand for reproducible and predictable 3D in vitro models that effectively replicate the tissue of interest. These systems need to

- replicate specific physical and biochemical aspects of the biological system.
- be readily manipulated to address specific research questions or target specific biological pathways
- be reproducible, scalable and critically, validated against the gold standards.

Scaffold-based models, based on tissue engineering knowledge, use both synthetic and natural materials to create a 3D framework to support cell attachment and growth. Examples include tissue engineered skin models built around decellurised tissue or collagen-1.[6]

There is also the opportunity to integrate from the earliest inception both *in situ* (ie embedded biosensors, reporter constructs, imaging) and *ex situ* tools (chemical spectroscopy, in silico models). These sensing systems enable real-time monitoring of the behaviour both during preparation and use, creating a 4th dimension to the cell culture systems. It is only with the development and incorporation of these tools that we can expect to develop systems that are validated, reproducible and scalable and thus implementable across the Medical Technology and Pharmaceutical sectors.

This talk will discuss the tools and systems we are using to investigate and validate the materials, sensors and construction principles required for reproducible, scalable and monitored 4D *in vitro* cell culture systems.

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M28: Enhancing brain plasticity: exciteBCI

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Stroke represents a massive health and societal burden worldwide, with 15 million people suffering a stroke each year. In many countries stroke is the number one cause of adult disability. The demand for rehabilitation services vastly outstrips the ability of health systems in developed and developing nations to provide rehabilitation. For people with stroke the lack of rehabilitation translates into poorer outcomes, with dire consequences of living with life-long physical disability.

exciteBCI wearable technology is a revolutionary approach to stroke rehabilitation. Using a brain computer interface to drive a neuromodulatory intervention, exciteBCI aims to promote neural plasticity. Using electroencephalography activity recorded from 9 sites over the cortex the brain computer interface predicts the time at which a person intends to move. This enables a precisely timed delivery of a sensory stimulation to a peripheral nerve or muscle. The mechanism of action is thought to be the induction of synaptic long-term potentiation (LTP) by the process of paired associative stimulation. We have demonstrated that this approach can induce neural changes to the cortex that outlast the stimulus for up to 60 minutes following intervention delivery. The miniaturisation of the laboratory equipment used in early studies of this approach is an important step in the development of an intervention that has a future as a cost-effective, smart, wearable technology which will improve outcomes for people with stroke.

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M29: Quantifying Insulin Adsorption in Hospital Delivery Systems

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Insulin adsorption to delivery materials has been well observed in clinical care, but not well quantified. Between 20-80% of insulin can be lost to adsorption in the first few hours of an infusion, depending on the clinical conditions. While materials science has elucidated some of the mechanisms of insulin adsorption to selected materials, no approach has quantifiably assessed the adsorptive loss of insulin to clinically relevant materials. Insulin adsorptive loss can result in persistent hyperglycaemia, which may lead to subsequent insulin over-dosing resulting in hypoglycaemia. Insulin adsorption may contribute to poor glycaemic control and glycaemic variability.

This work models insulin adsorption in clinical lines to enable predictive quantification of insulin delivery in care. Adsorptive capacity (IU/m^2) of two common infusion line materials is calculated from literature data, and compared to flow rate. It was found that adsorptive capacity decreased hyperbolically with increasing flow rate in both polyethelene (PE) and polyvinal chloride (PVC) infusion lines, indicating more total insulin is lost at slower infusion rates. Using this relationship, it is clear that in low flow (<1 ml/hr) and/or low concentration (<0.5 IU/mL) flows, insulin delivery is 30-60% of that intended.

This work shows that insulin loss to adsorption is material and flow dependant in common clinical infusion lines. The relationship between total adsorptive capacity and flow in a given line enables modelling of adsorption over a wide range of clinical conditions. Future work examines the time-dynamics of adsorption, with a view to bedside prediction of insulin adsorptive loss which can be accounted for in care. Such models will enable better use of bedside delivery technologies, improving glycaemic control care. Equally, such modelling approaches will be relevant for any protein-based drug delivery.

M30: Airflow Model to Investigate the Effect of Positive Airway Pressure on Human Epithelial Cells

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Non-invasive positive pressure ventilation, which is the first choice for providing mechanical ventilation in the intensive care unit, introduces compressed air into the respiratory system to help keeping the airways open. Positive airway pressure (PAP) devices, such as continuous positive airway pressure (CPAP) devices, are also used to treat obstructive sleep apnea or chronic obstructive pulmonary disease, and to deliver aerosolized medication for treatment of acute chronic respiratory failure. However, despite the broad PAP clinical application, the experimental conditions to reproduce realistic PAP on the airways are not studied.

Hence, the aim of this research is to determine how to simulate non-invasive positive pressure ventilation on human epithelial cells and use the optimized flow conditions in further investigations. Human nasal RPMI 2650 and bronchial Calu-3 epithelial cells grown in air-liquid interface (ALI) on permeable supports are used as a respiratory model. Three PAP different airflow were simulated and applied on both cell models. The resulting cell layer integrity and permeability was assessed with trans-epithelial electrical resistance (TEER).

The results show that the TEER values increased significantly after PAP application compared to the control, which suggest a possible compression effect. However, the three flow scenarios considered does not affect the TEER values obtained, which demonstrates that either of them can be used to simulate NIPPV in further investigations.

M31: Design and safety considerations for a portable jet injection controller

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Needle free jet injection uses the rapid application of high pressure to a liquid drug to form it into a high-speed jet, with sufficient momentum to penetrate the skin. By controlling this applied pressure, the depth of penetration can also be controlled, optimising the drug delivery process. However, controlling such a high-speed, high-energy process is challenging; using a lightweight voice coil actuator to apply the pressure[1], a power of up to 10 kW is required, with full-power control bandwidth of over 1 kHz. Furthermore, this must be done in the context of a medical device, which institutes strict requirements for safety isolation from high voltages and for reliability of performance.

We have developed a compact power system for jet injection that can balance these concerns, coupling a high voltage capacitor energy store to a high-bandwidth switching controller with extensive isolation. The system can operate independently or be controlled from a PC over a USB serial connection. In order to achieve the required switching frequency for high efficiency and for control, silicon carbide power semiconductors are employed in the switching controller. This controller is currently in use for human and animal clinical trials of controllable jet injection. In this presentation, I will discuss the design and performance of this system, with particular emphasis on the features used to achieve medical safety.

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M32: Jet Injection of Local Anaesthetic

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Jet injection is a transdermal drug delivery technique that forms the liquid drug into a high speed jet capable of penetrating the skin, and delivering itself into the underlying tissue. The key advantage of this technique is that it is needle-free so avoids the issues of needle-phobia, accidental needle stick, and sharps waste. However, as well as avoiding the use of a needle, jet injection can also result in a more dispersed distribution of drug within the tissue relative to delivery with a needle. This has possibly contributed to some findings that jet injection can result in an improved immune response to vaccines, and different time profiles of anaesthetic onset, and duration, relative to a needle based delivery.

In the needle-free jet injection team at the Auckland Bioengineering Institute we have developed highly controllable, motor driven jet injection devices. The potential advantages associated with the dispersed delivery resulting from jet injection have led us to investigate the use of our injectors for the delivery of local anaesthetic. We have pursued two quite different local anaesthetic applications: dental anaesthetic delivery, and 'needle-assisted' lateral jet injection for anaesthesia prior to skin grafts. In the dental application we developed a thin injection tip which allowed the injections to be comfortably performed throughout the mouth. This device was then validated through injections into the oral tissue of two human cadavers which were visualised using cone beam CT scans. For the transdermal application, we aimed to spread the anaesthetic underneath the skin at a single depth in an effort to numb a larger area. To achieve this we laser machined small holes into the walls of 27G needles and blocked the end of the needle such that fluid was only propelled laterally. These needles were mounted on the end of a jet injector and injections into porcine tissue were performed to observe the resulting dispersion.

M33: Hermeticity testing of implantable devices via optical leak testing

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Hermetic device packaging is vital for the long-term performance of implantable medical devices. Chronically implanted devices such as cochlear implants and pacemakers have typical operating lifetimes ranging from years to decades. This places burden on material selection and sealing techniques capable of maintaining a stable internal environment. However, regardless of the fabrication technique, fine leak channels are still present within the material or along the sealing interface[1]. Water passing through such pores can lead to the corrosion of electronic circuitry. Gas ingress into the reference cavity of pressure sensors would result in reading offsets. As implantable packages reduce in size to millimetre scales, device packaging must meet more stringent levels of leak-tightness.

The measurement of leakage into a hermetically sealed package is necessary to predict its performance and lifetime. Traditional test methods, such as a helium leak test requires exposing packages to a pressurized helium environment (bombing), followed by mass spectrometry to determine its leakage. Such tests are affected by the background helium in the atmosphere and typically require hours of bombing.

Recent advancements in Digital Holographic Microscopy (DHM) has allowed for real-time measurements of sub-nanometre displacements. This technique forms the basis of Optical Leak Testing (OLT), which is recognized for hermeticity verification in MIL-STD-883K TM 1014.13[2]. This method can be applied using a DHM (DHM-R2100, Lyncée Tec, Lausanne) for the hermeticity testing of an implantable pressure sensor. A fine leak-rate of 10^-10atm.cc/s is detectable for a sensor with internal volume of (10mm)^3, when monitoring the deflection of a 25um thick, pressure sensitive membrane. OLT is non-destructive and capable of simultaneous screening of multiple devices, reducing cost and test duration.

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M34: Development of a finite element model of the ovine stifle for biomechanical evaluation of TTA implants

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Sheep are a common animal model used to investigate orthopaedic conditions, particularly for *in vivo* studies. However, little effort has been concentrated on developing validated sheep finite element models (FEM) to streamline biomechanical research through *in silico* analysis. The purpose of this investigation was to develop a FEM of the ovine stifle in order to reliably and efficiently predict *in vivo* biomechanical performance of tibial tuberosity advancement (TTA) implants of varying material properties.

The model was comprised of the femur and tibia which were segmented from computed-tomography (CT) data of an adult sheep. The physiological material properties of the bony anatomy were derived from the Hounsfield values of the CT data and were mapped to the model geometry. A 'worst-case' loading was chosen, and the stifle was positioned at an angle where the peak axial force during gait had been reported *in vivo* [1]. The activated tibiofemoral muscle forces for this gait position were inserted [2], and a bed of springs was modelled at the tibiofemoral contact patch to emulate the load-transferring capabilities of cartilage. The natural anatomy was then morphed into a postoperative anatomy, incorporating the implant. Lastly, a tension band plate and four screws were installed. Locally-optimised designs, rather than homogeneous, were found to have 13% more area within the desired strain range reported to improve osseointegration [3], [4]. For a partial-osteotomy TTA surgery, it is common to see fracture at the tibial crest termination. When this was modelled, the increased stresses did not affect the mechanical integrity of the implant, but did predict an average increase of 2% in the desired strain range of the implant.

In conclusion, FE analysis has the ability to be an effective tool to inform implant design, which can lead to patient-specific implants better for surgical and treatment efficacy.

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M35: A dynamical tuning circuit for wireless power to optogenetic stimulator

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Optogenetics is an emerging deep brain stimulation technology which uses light to control neural activity of genetically targeted neurons with the aim of treating neurological disorders [1]. A promising approach to deliver light is implanting a micro optogenetic stimulator at the stimulation site. The implant contains a small coil that receives power wirelessly from an external transmitter. The small implant necessitates high operating frequency and low coupling factors leading to large coil quality factors. Furthermore, due to high coil Q, tight matching of primary and secondary tuning frequencies is necessary for wirelessly powered implants, which makes the system sensitive to component variation (such as capacitor aging) and environmental factors such as parasitic capacitance to earth or the impedance of nearby metal objects. However, tight tuning is required to minimize patient exposure to heating from SAR as detuning causes the primary to supply greater field strength to meet the load power. Therefore, it is necessary to tune the external transmitter for ensuring patient safety.

A dynamic tuning circuit based on a switched capacitor matrix is proposed which incorporates the MOSFET output capacitance into the design allowing for predictable tuning properties. It consists of n independently controllable switched legs leading to 2^n switching modes making its equivalent capacitance vary between 2^n discrete values. A parameter calculation method is presented to determine switching capacitor array values including compensation for AC switch parasitic capacitance. The parameter calculation determines the minimum number of switching network nodes based on circuit Q, component tolerance and minimum system efficiency.

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M36: Application Specific Integrated Circuit Design for Implantable Device: Challenges and Opportunities for Academic Research

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Pacemakers, spinal cord stimulators, deep brain stimulators and cochlear implants are all examples of commercially available implantable medical devices that are routinely used to treat medical conditions. Many of these devices already include application-specific-integrated-circuits (ASICs) to deliver highly specific functions in very small form factor packages. As academic research and industry drive implantable device development towards smaller, lower power and higher performance, the role of ASICs is growing. ASIC design provides a large scope for novel research but comes with many challenges, especially in countries with no integrated circuit design industry like New Zealand. Steep cost for design software and circuit manufacturing, long turnaround times for circuit fabrication, and lack of expertise in the field all present challenges to academic research into ASIC design.

Despite the challenges involved, we have develop a range of capabilities in ASIC design within the Auckland Bioengineering Institute. Our focus is on integrating the many features required for wireless power transfer, supply regulation and data transfer for which commercially available parts do not exist. Our group has developed a combined synchronous rectifier with power-flow-control allowing tens of milliwatts to be transferred wirelessly all in one ASIC only 1520µm by 620µm. This circuit replaces multiple components including diodes, comparators, resistors and low dropout voltage regulators moving us closer to mm scale implants.

M37: A Low Power Capacitance to Frequency Converter in 180nm CMOS for an Implantable Capacitive Pressure Sensor

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Pressure monitoring from a long term implantable device has the potential to greatly improve the lives of patients suffering from Hydrocephalus[1]. The imbalance between production and absorption of cerebrospinal fluid in these patients leads to increased intracranial pressure (ICP) resulting in a number of symptoms. Complications due to shunts, the current mainstay treatment, blocking, breaking or not working correctly are common and can be difficult to detect even with the use of CT scans and MRI. A tiny wireless implantable pressure transducer would allow continuous, long-term pressure monitoring and shunt failure detection for hydrocephalus and aid many other applications. A key component of any pressure implant is the transducer signal conditioning circuit which must be low power, high resolution and high accurate.

Therefore, we designed a readout circuit for an implantable capacitive pressure sensor based on the principle of capacitance to frequency conversion. This circuit is implemented in 180nm CMOS technology intended for pressure monitoring in the body. It is designed to sense pressure changes from 300mmHg to 1000mHg (capacitance range from 6pF to 7pF) corresponding to a frequency output range of 1.8MHz to 13.4MHz. The frequency output is modulated with a 1.63KHz clock and the number of cycles per period is counted. This readout circuit has a resolution of 0.28fF (0.196mmHg) with a power consumption of 72µW at 1.8 V supply. This offers simplicity, small circuit area, low power consumptions and easy interface to peripheral digital systems by counting using devices such as micro controllers.

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M38: Optimizing analog front end for non-contact biopotential sensing

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This study involves an investigation into developing an analogue front-end (AFE) for dry and non-contact biopotential sensing. Measurement of biopotentials such as Electrocardiogram (ECG) and Electroencephalogram (EEG) have evolved from conventional wet electrode application to using dry, non-contact measurements to provide for user comfort and portability. However, it is very well established that while the gel electrodes cancel the high electrode-skin impedance, dry electrodes require additional measurement circuitry to acquire signals without gel. The components used in the analogue front-end circuit are crucial to its performance in picking up the required biopotential and hence require extensive attention to their properties in enhancing the overall improvement of the AFE.

Here, we study the components in a AFE circuit and investigate into the factors which lead towards choosing them. This study focusses on analysing the sensitivity of the measurement towards the component tolerances and the overall performance of the AFE under several component values. The objective of this work is to attain an understanding of the contribution of different components to the performance of the AFE and aid in designing better electronics for state-of-the-art biomedical sensors for physiological monitoring.

M39: General-Purpose Stimulator IC for Optical and Electrical Stimulation

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Implantable devices need small and functional electronics. The technology of integrated circuits (ICs) presents a solution to miniaturisation of electronic circuits without compromising and often improving on their performance and functionality. One IC development effort at the Auckland Bioengineering Institute that has been carried out in collaboration with the Bionics Institute is the design of a general-purpose Stimulator IC for optical and electrical stimulation.

ICs have long development and manufacturing times. Thus, making a custom application-specific IC (ASIC) for each application can be uneconomic. One design goal of this Stimulator IC was to achieve a flexible and modular building block that can fulfil requirements of many projects. This chip is a 20-channel stimulator that can deliver both pulsed and fully analog current waveforms when controlled by an external microcontroller via the SPI link and its DAC output. The packaged chip will take 6 mm x 6 mm of board area. The chip can be powered from 3 to 15 volts and consumes 20 uA of static current when idle. The IC can deliver currents from a few microamps to tens of milliamps. In this current range, its output impedance scales from hundreds of kiloohms to several gigaohms, which helps to achieve precise matching among current pulses. The chip includes a voltage regulator to supply lower-voltage internal and external components and an active attenuator to facilitate external telemetry of high-voltage electrode signals. For the needs of electrical stimulation, the IC implements a novel function of charge monitoring that automatically extends the stimulation time when the integrated current source runs out of voltage compliance. This simplifies system design and makes it possible to use lower supply voltages in some applications when compared to simpler stimulator implementations.

M40: STAR-GRYPHON in the Neonatal ICU: Achieving Safe and Successful Glycaemic Control

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Hyperglycaemia is a common complication of stress and prematurity in very/extremely premature infants in the neonatal ICU (NICU), and is associated with increased morbidity and mortality. Insulin therapy is often used to treat hyperglycaemia, though fear of hypoglycaemia may reduce its use. This study evaluates 6 years of STAR-GRYPHON, a model-based glycemic control protocol for the NICU.

STAR-GRYPHON uses a physiological model to estimate patient-specific, time-varying insulin sensitivity (SI). Statistical models forecast likely future changes in SI, and thus blood glucose outcomes for any insulin dose. STAR-GRYPHON optimizes insulin dose so BG outcomes overlap the 4.0-8.0mmol/L target range with 5% maximum risk of BG<4.4 mmol/L.

STAR-GRYPHON has been utilized in Christchurch Women's Hospital NICU on a tablet-computer since January 2013. Patient-episodes with >12 hours of insulin (starting criteria: 2 consecutive BG>10mmol/L) are compared to retrospective care (n=25; 3098hours). Safety (%BG<4mmol/L, BG<2.6mmol/L), performance (%BG in 4.0-8.0mmol/L, %BG>10mmol/L), and clinical workload and burden on the neonate (measurement interval) are assessed.

From January 2013- 2019 STAR-GRYPHON (n=59 episodes, 4929 hours) was more effective (Median [IQR] BG was: 7.2 [6.2-8.5]mmol/L vs. 7.9 [6.6-9.2]mmol/L; 66% vs. 52% BG in 4.0-8.0mmol/L; 9.6% vs. 16.4% BG>10mmol/L) with improved safety from mild hypoglycaemia (0.46% vs. 2.1% BG<4.0mmol/L), and comparable hypoglycaemia (0.06% vs. 0.1% BG<2.6mmol/L, in 5% vs. 4% of patients) compared to retrospective care. Workload and blood draws are reduced, with an average measurement interval under STAR-GRYPHON of 4.0 [3.9–4.2] vs. 3.2 [2.7–3.8] hours. This last year revealed an increase in persistent hyperglycaemia despite insulin, as the first 5 years of STAR-GRYPHON had 71% BG in 4.0-8.0mmol/L.

STAR-GRYPHON, used as a standard of care in Christchurch Women's Hospital, provides tighter control for lower clinical workload compared to retrospective data. Tighter and safer control is a starting point for assessing the benefits of reduced hyperglycaemia.

M41: Interpretable Deep Learning for Mortality Prediction Inside the Intensive Care Unit

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Intensive Care Units (ICUs) have helped make improvements in mortality, length of stay and complication rates among patients. To improve ICUs, the field of bio-statistics has developed a series of scores which try to predict the likelihood of negative outcomes. These help evaluate the effectiveness of treatments and clinical practice, and also to identify patients with unexpected outcomes. However, they have been shown by several studies to offer sub-optimal performance[1,2]. Alternatively, Deep Learning offers state of the art capabilities in certain prediction tasks and research suggests deep neural networks are able to outperform traditional techniques[3] . Nevertheless, a main impediment for the adoption of Deep Learning in healthcare is its reduced interpretability, for in this field it is crucial to gain insight into the why of predictions, to assure that models are actually learning relevant features instead of spurious correlations. To address this, we propose a deep multi-scale convolutional architecture trained on the Medical Information Mart for Intensive Care III (MIMIC-III)[4] for mortality prediction, and the use of concepts from coalitional game theory to construct *post-hoc* visual explanations aimed to show how important these inputs are deemed by the network. Results show our model attains a ROC AUC of 0.8735 ($\pm$ 0.0025), overperforming traditional statistical scores used for mortality prediction as SAPS-II, without sacrificing interpretability.

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M42: A Direct-drive Linear Actuated Assistive Device for the Shoulder

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Standard one-to-one stroke therapy is a labour intensive and costly process, often resulting in fatigue for the therapists and shorter training sessions than required. Although robotic rehabilitation addresses these issues, most current robots are complex, stationary and limited to repetitive motion in clinical environments.

We present the detail design for a single degree of freedom robot that can provide gravity compensation assistance at the shoulder in performing activities of daily living (ADLs) and during stroke rehabilitation. The robot consists of a single direct-drive linear permanent magnet synchronous actuator connected to the arm and hip via two spherical joints to lift up or lower down the arm in any orientation. This class of actuator has high force transparency and bandwidth, which is highly advantageous for an assistive device; however, traditionally suffers from low force density. We derive a detailed kinematic model for the robot to find the robot optimal attachment location on the arm. We also demonstrate that a single design of this device can be fitted to a wide range of patients.

Based on these results, we describe the design of a suitable actuator, using a semi-analytical electromagnetic model to optimise efficiency and a finite element approach to subsequently minimise cogging forces. The resulting actuator requires approximately 85W of power to generate 100 N force to support the outstretched arm (at 90 degree); we present a thermal design to remove this heat by forced air cooling using a 40 mm high static pressure fan. The overall mass of the robot is 1.5 kg, which is appropriate for the wearable assistive device.

M43: System Identification Techniques to Diagnose Rotator Cuff Injuries

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Rotator cuff injury is the most common cause of shoulder related pain and disability. It accounts for 4.5 million clinician visits in the United States every year with management cost of seven billion dollars in the year 2000. A wide range of clinical tests are currently used to diagnose rotator cuff injuries. However, clinical tests of rotator cuff injuries are unreliable and ineffective for precise diagnosis and rely upon clinicians' experience and intuition. One potential alternative for diagnosing rotator cuff injuries is to use system identification techniques to interrogate the function of the glenohumeral joint. System identification is defined as the process of estimating the mathematical model that describes a particular system when both input and the output are known. To perform system identification on the rotator cuff muscles, a perturbation robot has been designed to generate angle or torque perturbations about the ab/ adduction and internal/ external rotation axes of the glenohumeral joint, and to measure the corresponding output torques or angles. Then, techniques of system identification and parameter estimation will be applied to characterise the dynamics of the rotator cuff for both healthy and injured groups of participants. We will correlate the measured dynamics changes to the presence and severity of injury. The aim of this project is to build a diagnostic device based on characterising the dynamics of the rotator cuff muscles. We will correlate the measured stiffness changes to the presence and severity of injury. In addition, we intend to collect stiffness data from both healthy and injured participants in different conditions. These data will be important for future studies to refer to. Our long-term vision is for this tool to be used in hospitals, and, as such, its cost, invasiveness, reliability and accuracy for diagnosis will be taken into consideration.

M44: A Hybrid Ankle Foot Orthosis to Augment Walking

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Ankle-foot orthoses (AFOs) are commonly prescribed for patients with lower limb pathologies, such as stroke and cerebral palsy. This research seeks to develop a hybrid ankle-foot orthosis (HAFO) capable of returning and storing elastic energy as well as producing positive power offering new possibilities for assistance during gait. The HAFO incorporates a clutch-spring mechanism, two direct drive linear actuators and sensory techniques based on physiological measurements that can augment walking in healthy subjects by reducing the energy cost of gait, and further can be prescribed to overcome gait abnormalities in patients after stroke[1].

The energy storage mechanism requires a clutch with both a high holding force and a low mass[2]. The prototype of the clutch was fabricated and tested. The experimental results validate the mechanical properties of the system. A solenoid-driven friction clutch was chosen to permit maximum flexibility in control. A prototype of the clutch was constructed, and its response time and load capacity were experimentally validated. The clutch was shown to hold the required load, and to change states in less than 30ms, which is sufficient for normal human walking. We anticipate the characteristics of the clutch can make it an appropriate choice to be incorporated into parallel elastic exoskeleton designs to engage and disengage the spring and thereby increase gait economy while not constraining the leg during swing.

To provide active mechanical assistance, direct drive linear actuators has been used. The motors can mimic skeletal ankle muscles and provide bi-directional assistive torque to actuate two ankle rotational DOFs. The motors (each with power: 100 W, stroke length: 160 mm, and mass: 700 g) together can provide up to 35 Nm of torque.

Ultimately, we intend for the results of this study to support future work in gait rehabilitation for stroke patients and in human augmentation for industrial tasks.

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M45: An EMG-based torque estimation method for Robot-assisted rehabilitation with an assist-as-needed control approach.

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It is significantly important to find a reliable robotic intervention to respond to the increasing rehabilitation demands worldwide. The main challenge in robotic rehabilitation is providing high subject involvement over long-duration therapy sessions. The assist-as-needed (AAN) control approach has been introduced to address this challenge. In this approach, the level of robot intervention modulates by the subject movement intentions.

The first step to introduce a suitable AAN controller is having an accurate estimate of movement intention. In this research, a novel motion pattern recognition method is proposed, which is capable to estimate joint torque in real-time. In particular, the joint torque is estimated based on the level of muscle activation and kinematic features of the joint. In detail, the EMG signals of five muscles alongside the angular position and velocity of ankle joint were used as input for a surrogate model to estimate the relative joint torque. Two novel neural network structures, recurrent neural network (RNN) and non-linear Autoregressive (NARX) network were designed and evaluated as a surrogate model. The standard deviation (SD) of the difference between estimated ankle torque and calculated values from inverse dynamic equations considered as the performance criterion.

The primary test on a healthy subject, normal walking data, showed that the accuracy of both models was significantly higher than mathematical hill-type EMG-based muscle model while NARX was relatively more accurate than RNN, (Error SD for Hill-type: 14.24, RNN: 7.89 and NARX: 6.18). The results imply the ability of the developed models in active joint torque prediction. Moreover, the training process of the developed models is fast enough to introduce an adaptive surrogate model that can continuously update with a new relation between EMGs and torque, and solve the problems related to the time-varying property of EMG signals because of sweating and electrode displacement.

M46: Optimization of multi-channel body-surface mapping electrode array materials for electrogastrography (EGG)

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BACKGROUND & AIM: Motility of the gastrointestinal tract is a critical part of digestion. In the stomach, contractions of gastric smooth muscles are governed by an electrical activity known as slow waves. Arrhythmia of gastric slow-waves is associated with a number of clinically challenging digestive conditions, but an accurate and routinely deployable detection method is presently missing.

Electrogastrography (EGG) is a non-invasive method of recording slow-waves from the body surface, which requires an adequate number and resolution of electrodes in order to interpret the data. The main aim of this study is to develop a multichannel body-surface mapping array with sufficient signal quality and easy-to-use for clinical EGG and other electrophysiological applications.

METHOD & RESULTS: The effects of conductive gel (ECI Electro-Gel, Electro-Cap International, Inc., USA), and conductive paste (TEN20, Weaver and Company, USA) with 1-cm-diameter Ag electrodes were tested on six subjects and compared against ECG electrodes (Kendall™/Covidien Medi-Trace® 200 Series, USA). Preliminary data found that the conductive gel provided a higher signal-to-noise ratio (SNR) than the conductive paste and ECG electrodes by 29% and 68% respectively, where the EGG signal is below 0.1 Hz. The conductive paste and the ECG pad did not show a significant difference in SNR ($p>0.05$). The ECG electrodes provided better adhesion with foam at the electrode-skin sites and therefore the recordings were less prone to motion artefacts. In contrast, the conductive gel and paste didn't provide strong skin contact. The electrodes were more likely to lose skin contacts and recording due to minor movement.

CONCLUSIONS & FUTURE WORK: Conductive gel provided a greater SNR in recordings, but not strong skin contact, compared to the conductive gel and ECG electrodes. In future, electrode arrays and active electrodes will be developed and investigated to improve the coverage and quality of the EGG.

M47: Novel method of measuring pudendal nerve and external anal sphincter function

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Background

Faecal incontinence afflicts one-in-eight New Zealanders, yet effective electrophysiological diagnosis of its aetiology remains challenging. Continence is maintained via intact pudendal nerves (S2-4) and external anal sphincter. Current clinical testing of this neuro-musculature is unreliable and limited to the St. Mark's electrode[1].

Methods

Sphincter potentials were evoked via trans-sacral magnetic stimulation (TSMS) delivered by Magstim Rapid² (MagStim Company, Dyfed, UK), with a 70mm figure-of-eight coil. High-resolution electromyography (HR-EMG) of the sphincter was measured using a custom anorectal probe (FlexiMap, New Zealand). Probes 14mm or 16mm in diameter were constructed from thermoplastic polyetherimide and bonded to an array of 64 electrodes spaced 1cm apart in an 8x8 circumferential array. Evoked electrical sphincter activation was measured in high-resolution to understand the sequence, latency and velocity of activation.

Results

Preliminary studies involved three healthy males with average baseline faecal incontinence severity index of 7.7/61 and St. Mark's Incontinence Score of 1.3/24. Early trials have established methodological feasibility, safety and a diagnostic workflow. HR-EMG correlated to anorectal manometry and gentle squeezes were lower in amplitude than tight squeezes, demonstrating feasibility. Median visual analogue pain score was 1/10 during probe insertion and 0/10 during magnetic stimulation. Median discomfort during probe insertion was 3/10, median discomfort during magnetic stimulation was 1/10 and median discomfort throughout procedure was 2/10. The overall procedure was tolerated well by patients and resulted in no adverse events. Methodological feasibility was tested in healthy individuals where

Conclusion

HR-EMG recordings of evoked sphincter potentials via TSMS was a feasible, safe and patient tolerable method of evaluating pudendal nerve and external anal sphincter function. Further trials are planned to validate this methodology against the St. Mark's electrode and anorectal manometry in healthy and incontinent patients. HR-EMG with TSMS aims to fit into routine pelvic floor physiology testing alongside endoanal ultrasound and manometry.

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M48: High-resolution Slow Wave Mapping of the Lower Gut in Rabbits

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A century of research has been spent on defining the mechanisms underlying gastrointestinal (GI) motility. A major barrier has been the complexity of capturing bioelectrical events from these deformable organs.

Bioelectrical activity of the gut involves interacting events from myogenic slow waves and spike potentials. These events, coordinated by interstitial cells of Cajal (ICC), initiate and govern peristalsis necessary for the efficient breakdown and digestion of food. Degradation of these bioelectrical ICC networks have been associated with functional gastrointestinal (GI) motility disorders, including gastroparesis and dyspepsia. Functional GI disorders are common in New Zealand affecting up to 25% of the population, and patients suffer a poor quality of life with symptoms of pain, nausea, bloating and vomiting. The problem is exacerbated due to the difficult diagnosis of GI disorders, with absence of the capability to diagnose definitive symptoms in patients.

We have developed new methods of applying compliable, high-resolution, bioelectrical arrays that significantly improve contact to the pliable and irregular topology of the lower gut thus improving signal quality and data acquisition of bioelectrical events. An *in-vivo* rabbit model was utilised to capture and define for the first time the unique, integrated bioelectrical activity in the lower gut.

Pilot studies in 4 rabbits have demonstrated improved electrode compliance enabling bioelectrical slow wave and spike recordings from multiple sections of the lower gut. These new methods provide a platform to perform implantable, long-term chronic studies and have the potential to conform to other complex anatomical sections of organs including the atrial and ventricle wall of the heart. Outcomes of this work will not only contribute to discovering the electrophysiological mechanisms of lower gut function but also contribute to the development of novel GI diagnostics and therapies.

M49: Novel microelectrode arrays for measurement of bio-electrical activity in the gut.

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Bio-electric myogenic slow waves are the governing electrophysiological component for coordinating motility, which is critical to sustain life. The most widely used current approach for measuring slow wave activity in the gut is to utilise electrode arrays on either the serosal or the mucosal surface of the organ. There are no extracellular in-vivo attempts to date to discover any electrical activity across the gut wall, nor any microelectrode arrays capable of measuring electrical activity on smaller organs or regions at a high resolution.

Four new microelectrode arrays have been developed with high spatiotemporal resolution in the form of linear needles (8-12 electrodes, 0.25-1 mm spacing), two-dimensional flexible arrays (8 electrodes, 0.7 mm apart), brush arrays (8-16 brushwires), and glass chips (8 electrodes,3 mm spacing). These novel techniques enable both transmural and serosal bio-electric slow wave recordings on smaller regions and organs of the gut. The manufactured electrode arrays have undergone and passed benchtop testing using realistic synthetic signals to validate its robustness and reliability. The electrodes are currently being applied in experimental studies in pigs from which successful serosal and transmural slow wave activity have been recorded. These results will be followed by quantitative signal analysis (signal-to-noise ratio, morphology correlation and activation mapping). In future, we will apply these techniques on transgenic smaller animals to assess various phenotypes motility disorders.

As a result, these new arrays will provide an improved understating of gut electro-pathophysiology in functional motility disorders such as gastroparesis, functional dyspepsia, and stomach cancer. In addition, these techniques are valuable in pharmaceutical studies for drug discovery and pre-clinical trials, and for validating the efficacy of novel therapies such as pacing, stimulation and ablation. Most importantly, these methods can be translated to other organs in the body such as the heart and brain.

M50: Organic electrochemical transistor for measuring blood glucose concentration in a jet injector

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Diabetic patients have to monitor their blood glucose concentrations at least four times a day however, piercing the skin and obtaining blood is the most inconvenient process for them. It has been demonstrated that a high-pressure jet of fluid from a needle-free jet injector can penetrate the skin, and by reversing the injector, injectate and interstitial fluid can be withdrawn. In this research, it is proposed to combine blood extraction directly with glucose assaying through a jet injector. However, according to previous information it is clear that the withdrawn blood will be mixed with the injected fluid. In order to measure glucose concentration in extracted fluid, organic thin film transistor is chosen to measure glucose concentration.

Recently there has been an increasing interest in organic thin film transistors (OTFT). OTFTs consist of a layer of an organic semiconductor on a nonconductive substrate with three different electrodes. These transistors are categorized in two different groups: organic electrochemical transistors (OECTs) and organic electric field transistors (OEFTs). In comparison OECTs are more suitable than OEFTs in sensing glucose.

In this research, organic electrochemical transistor is fabricated to sense glucose concentration in the extracted fluid from jet injector. Gate, source and drain are made by gold sputtering technique on a slide of glass. As the channel, PEDOT: PSS (poly (3, 4-ethylenedioxythiophene) polystyrene sulfonate) is printed by Fujifilm Dimatix Piezoelectric inkjet printer between source and drain. Electrolyte is in direct contact with channel and gate. Considering the transistor's delay time drain-source current is measured versus drain- source voltage at different gate- source voltages. It is shown that organic electrochemical transistor with gold gate electrode can detect glucose up to 1 mmol/L in buffer solution.

M51: A needle-free jet injection device for blood release

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Diabetes mellitus is a metabolic disorder and one of the leading causes of death by disease. The International Diabetes Federation estimated that 1 in 11 adults has diabetes, for a total of 425 million adults globally in 2017[1]. Patients with diabetes perform skin prick tests by using lancets to obtain blood samples for glucose monitoring several times per day. Patient compliance is poor with this process due to the resultant pain, needle-stick injuries and needle-phobia. In order to make this process easier for diabetic patients, we are investigating whether it can be replaced by a needle-free jet injection device.

Needle-free jet injection is a drug delivery technique that uses a high-speed stream of liquid drug to penetrate skin and deliver the liquid into underlying tissues. In some cases, jet injection through the skin can result in the release of blood from the capillary network. The shape of the nozzle through which jet is created has an impact on jet shape, and on the shape of the resulting tissue incision. Different designs of custom orifices were simulated and high aspect ratio cross-sectional rectangular jets are chosen since they have the potential to penetrate skin and open capillaries in a manner similar to that of a finger-prick lancet. Intradermal jet injection into pig skin with a volume of less than 50 µL is possible to disrupt small blood vessels including capillaries through histological analysis. The wound geometry and the extent of disruption of capillaries resulted from the custom slot-shaped orifices will then be compared to that from the lancet pricks. A future human study on capillary blood extraction with jet injection technology using custom orifices compared with a lancing device will be conducted to investigate the volume and concentration of blood collected.

1. N. H. Cho *et al.*, *IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045*, *Diabetes Res. Clin. Pract.*, vol. 138, pp. 271–281, Apr. 2018.

M52: Biodegradable polymer blends/composites, with high performance characteristics, for packaging application

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The awareness about the environmental pollution, caused by traditional polymers such as polyethylene, polypropylene, polystyrene, PET, PVC etc., growing concern about limited petroleum reserves and government regulations have resulted in increased research activity on environment-friendly, bio-based, biodegradable polymers, for packaging application. Many biodegradable polymers, bio-based as well as petroleum-based, have been developed for packaging applications. However, their wide spread application is limited mainly because their inferior performance characteristics and due to high cost. Most of the commercially available biodegradable polymers does not have the desirable properties. Research on many polymer blends and composites have been reported but considerable knowledge-gap exists especially on barrier properties and biodegradability characteristics of many polymer blends under home composting (ambient temperature) and in seawater environments. Hence additional research work is needed to fill the knowledge- gaps, to improve the packaging material characteristics. The present project aims at development of flexible polymer films, with high performance characteristics, suitable for packaging application. This involves blending various commercially available biodegradable polymers, modification of polymer blends with the addition of biodegradable additives, followed by hot pressing to fabricate flexible polymer films and detailed performance characteristics. The present research output is expected to assist in expanding the usage of biodegradable polymers, reduction of environmental pollution and accelerate the progress towards a sustainable future.

M53: Eliminating effect of air-gap through multi-channel ECG acquisition

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Electrocardiogram (ECG) is probably the most significant physiological modality which exists as a marker for cardiovascular risk assessment. Conventionally, ECG is measured using gel electrodes (12-lead ECG being the clinical standard). However, the technique has evolved into replacing gel electrodes with dry electrodes or wearable textiles which provide more user comfort but do not provide as good a signal quality. Several works and methods exist that propose to better the signal quality using dry electrodes, which have since also evolved into capacitive sensing of ECG.

This work presents a new approach to cancel the varying impedance between electrode and skin due to an existing air gap in case of non-contact ECG sensing. This study aims to extend the current state of ECG measurement from capacitive sensing to non-contact capacitive sensing through multi-channel ECG acquisition. The technique involves using at least two channels for measuring ECG and using a novel mathematical model to cancel the effect of impedance due to the existing air gap. The mathematical model involves frequency domain processing of the two signals to cancel the air gap impedance and obtain an estimate of the ECG measured directly from skin's surface. The objective is to integrate this methodology as a system-on-chip (SoC) to develop a prototype for non-contact ECG sensing under conditions of both contact or non-contact for ambulatory, continuous monitoring.

Summary of Abstracts for the Poster Session

Please display your posters during both poster sessions in the Marquee

Thursday 12.30pm -1.30pm

And

5.00pm – 6.30pm

No.	Title	Presenter	Institution
M33	Hermeticity testing of implantable devices via optical leak testing	Dixon Leung	University of Auckland
M34	Development of a finite element model of the ovine stifle for biomechanical evaluation of TTA implants	Josephine Shum	University of Otago
M35	A dynamical tuning circuit for wireless power to optogenetic stimulator	Rui Jin	University of Auckland
M36	Application Specific Integrated Circuit Design for Implantable Device: Challenges and Opportunities for Academic Research	Robert Gallichan	University of Auckland
M37	A Low Power Capacitance to Frequency Converter in 180nm CMOS for an Implantable Capacitive Pressure Sensor	Chaoping Zhang	University of Auckland
M38	Optimizing analog front end for non-contact biopotential sensing	Anubha Kalra	Auckland University of Technology
M39	General-Purpose Stimulator IC for Optical and Electrical Stimulation	Stepan Lapshev	University of Auckland
M40	STAR-GRYPHON in the Neonatal ICU: Achieving Safe and Successful Glycaemic Control	Jennifer Knopp	University of Canterbury
M41	Interpretable deep learning for mortality prediction inside the ICU	William Caicedo	Auckland University of Technology
M42	A Direct-drive Linear Actuated Assistive Device for the Shoulder	Soroosh Haji Hosseinnejad	University of Auckland
M43	System Identification Techniques to Diagnose Rotator Cuff Injuries	Yahya Z Yahya	University of Auckland
M44	A Hybrid Ankle Foot Orthosis to Augment Walking	Mahsa Momtahan	University of Auckland
M45	An EMG-based torque estimation method for Robot-assisted rehabilitation with an assist-as-needed control approach	Homayoon Zarshenas	University of Auckland
M46	Optimization of multi-channel body-surface mapping electrode array materials for electrogastrography (EGG)	Atchariya Sukasem	University of Auckland
M47	Novel method of measuring pudendal nerve and external anal sphincter function	Chris Varghese	University of Auckland

M48	High-resolution Slow Wave Mapping of the Lower Gut in Rabbits	Kiara Miller	University of Auckland
M49	Novel microelectrode arrays for measuring bioelectrical activity in the gut	Nipuni Nagahawatte	University of Auckland
M50	Organic electrochemical transistor for measuring blood glucose concentration in a jet injector	Bahareh Madadkhahsalmassi	University of Auckland
M51	A needle-free jet injection device for blood release	Jiali Xu	University of Auckland
M52	Eliminating effect of air-gap through multi-channel ECG acquisition	Gautam Anand	Auckland University Of Technology
M53	BIODEGRADABLE POLYMER BLENDS/COMPOSITES, WITH HIGH PERFORMANCE CHARACTERISTICS, FOR PACKAGING APPLICATION	Srinivasan Govindan	AUT