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## Medical Devices And Instrumentation

**1. A Smart Triggering Method To Reduce The Power Consumption Of The Barometer In A Low-Power Fall Detector**

**Wei Lu [1] , Michael Stevens[1] , Changhong Wang[2] , Stephen Redmond[1] , Nigel Lovell[1]**

1. *University of New South Wales Sydney, Kensington, New South Wales, Australia*
2. *Baylor College of Medicine, Houston, Texas, United States of America*

**The inclusion of a barometer in a wearable fall detector has been shown to improve the detection accuracy by measuring the altitude change associated with a fall event. However, the barometer is a high-power-consuming sensor. In a fall detector previously developed by our group, the barometer accounts for over 71% of the overall power consumption. In this study, we make use of a hermetically-sealed and waterproof enclosure, with a small inlet covered by a semi-permeable membrane (SPM) to delay the time at which equilibrium between the internal and external pressures is reached. This mechanism allows the barometer to be woken from power-down mode and capture the rising air pressure caused by the decrease in altitude during a fall event. The duration that the barometer is in the active mode can therefore be minimised, without compromising the fall detection accuracy. The data from a laboratory-based trial and a free-living trial using the prototype devices were used to assess the sensitivity and false alarm rate of the proposed fall detector. Also, the battery life of the proposed fall detector was estimated by combing the data from the free-living trial and a series of benchtop electrical tests. The thresholds of the fall detection algorithm were optimised with a two-objective optimisation approach to: (i) maximise the sensitivity; (ii) minimise the false alarm rate. The optimisation result was a Pareto front, which comprises a set of optimal compromise solutions (threshold combinations). The results show that the proposed fall detector achieves a minimum false alarm rate of 0.058 alarms/hour with a sensitivity of 91.5%. The maximum sensitivity is 94.5 %, while the false alarm rate increases to 0.603 alarms/hour. Assuming the proposed fall detector is powered by a lithium-polymer 3.7 V, 450 mAh battery, the battery life will be 1135 days.**

**2. Design And Fabrication Of Detachable Transport Monitor Mount**

**Cindy CW Wang[1] , Luke LK Khoo[1] , Voon CV Chin[1]**

1. *Royal Prince Alfred Hospital-Sydney Local Health District, Camperdown, New South Wales, Australia*

**Device handling is always a challenge in chaotic clinical environment especially during patient transport. A practical solution was requested to provide a secure mounting for transportable devices in limited bed spaces. As a solution, a detachable transport monitor mount was designed and fabricated in Biomedical Engineering department (BME) of Royal Prince Alfred Hospital (RPAH, Camperdown, Australia) and has been used in ICU and Emergency department (ED) for daily patient transportation between departments.**

**The design criteria have been determined as per clinical requirement and consultation with clinical staff with main focus on safety, easy operation and infection control friendly. The development has 3 phases: clamping version, lateral secure bar version and final parallel locating bar version to achieve the required purpose. Two types of final products have been fabricated in mechanical workshop of BME RPAH which fit to Hill-Rom and Stryker patient bed respectively in ICU and ED. Verification and Validation test are performed to exam the specification requirement criteria such as applicable weight loading limit and bed angle. Risk assessment has been conducted to mitigate any potential risk during clinical use.**

**The product has gained positive feedback from clinical users and approved a safe and enhancement for devices handling during patient transport. A number of requests have been received for fabrication for clinical use. This jig proves to be a simple and effective solution where any BME with mechanical section will be able to fabricate at ease. This solution improves the safety and workflow in hospital environment.**

**3.Design Of A Dual Lung Anaesthetic Gas Exchange Simulator**

**Rebecca Bailey[1]**

1. *Melbourne Health, Parkville, Victoria, Australia*

**The advancement of new techniques for measuring gas exchange requires the development of new in vitro simulators. There has been a steady development of in vitro gas-exchange simulators. Vartuli, Burfoot et al. (2002) described a method for producing 'apparent' lung-gas uptake for respiratory and anaesthetic gas (nitrous oxide) based on the insertion of diluting gases into an adult test lung bellows. The simulator described by Vartuli has been iteratively refined by Stuart-Andrews, Peyton et. al (2004) and Peyton, Ramani et al. (2005) who introduced controlled suctioning. The enabled the production of**

**realistic multi-gas exchange which enabled replication of uptake flow rates for oxygen, nitrous oxide and isoflurane while consuming carbon dioxide.**

**We describe further enhancements of the anaesthetic gas exchange simulator design explored by Vartuli, Stuart-Andrews and Peyton (2002, 2004, 2005). The new system provides electronic control of inserted gas flows which enables rapid application of step changes. Combined with the use of mixed gas suctioning positive and negative changes in individual gas uptake flow rates can be achieved. These changes enable simulation of isoflurane excretion through the additional of a vapouriser, and can produce independent gas exchange for the left and right lungs; including production of isoflurane uptake and elimination at substantially lower uptake flow rates.**

**The simulator described was developed for the improvement and in-vitro validation of a method for measuring cardiac output based on the throughflow of isoflurane from the left to right lung; where simulated lungs were tidally ventilated from two independent anaesthetic gas delivery systems.**

## Biomaterials and Tissue Engineering I

### 1. Feasibility Study Of 3D Graphene-Alginate Scaffold For Tissue Engineering Applications

**Negar Mansouri[1], Said Al-Sarawi[1], Jagan Mazumdar[1], Dusan Losic[2]**

1. *School of Electrical and Electronic Engineering, University of Adelaide, Adelaide, South Australia, Australia*
2. *School of Chemical Engineering, University of Adelaide, Adelaide, South Australia, Australia*

**Numerous efforts have been made in tissue engineering and regenerative medicine fields in order to produce functional replacements which restore malfunction tissues or organs. Several polymer-based scaffolds have been contributed in cellular growth and tissue reconstruction. However, it has appeared that composite materials with modifiable physical, mechanical and chemical characteristics are more appropriate for the fine control of cellular microenvironment and behaviour. Graphene derivatives have been found as a promising candidate which provide a biocompatible, conductive and porous structure for satisfactory tissue regeneration. In addition, it is hypothesized that deficiencies in alginate could be overcome by incorporating graphene in the composite material. This paper reports the fabrication of 3D scaffold based on graphene/alginate by a simple and eco-friendly method. The physical, chemical and electrical characteristics of obtained scaffolds have been examined by various characterization methods such as Fourier transform infrared (FT-IR), Raman spectroscopy (RS), Thermogravimetric analysis (TGA), Cyclic Voltammetry (CV) and Scanning electron microscopy (SEM). The graphene/alginate scaffold has a good mechanical strength and with pore sizes ranging from 70-250µm to facilitate optimal cell infiltration. Incorporation of graphene could provide a much better charge injection ability which can effectively lead to enhancement of electrical stimulation performance. Subsequently, the characterization techniques approve the capacity of porous graphene/alginate composite for the construction of electrically conductive scaffolds for tissue engineering applications. In conclusion, this study proposed that the graphene-based scaffold represents a suitable structure for engineering damaged tissues and requires further investigation as a model for understanding cellular behaviour, function, and circuit formation.**

### 2. Modulating Blood-Surface Interface: Biofunctionalisation Of Silk Biomaterials With A Vascular Molecule Using Plasma Immersion Ion Implantation

**Kieran KL Lau[1], Sally FT Tang[1], Megan ML Lord[1], John JW Whitelock[1], Marcela MB Bilek[2345], Jelena JRK Rnjak-Kovacina[1]**

1. *Graduate School of Biomedical Engineering, University of New South Wales, Sydney, NSW, Australia*
2. *School of Physics, University of Sydney, Sydney, New South Wales, Australia*
3. *Charles Perkins Centre, University of Sydney, Sydney, New South Wales, Australia*
4. *School of Aerospace, University of Sydney, Sydney, New South Wales, Australia*
5. *Australian Institute of Nanoscale Science and Technology, University of Sydney, Sydney, New South Wales, Australia*

**Publish consent withheld**

## Biomaterials & Tissue Engineering II

**1. Optimised Biomimetic Surfaces Toward Novel Bioengineered Vascular Grafts**

**Shouyuan Jiang[1] John Whitelock[1] , Jelena Rnjak-Kovacina[1] , Megan Lord[1]**

1. *University of New South Wales, Sydney, New South Wales, Australia*

**Synthetic vascular grafts uniformly fail in small diameter (<6 mm) vessel applications, including coronary and peripheral vascular bypass surgery. The major complications leading to graft failures are thrombus formation and neointimal hyperplasia, which occur primarily due to lack of endothelium on the graft-blood interface, leading to platelet adhesion or smooth muscle cell (SMC) proliferation. This project aims to develop a biomimetic graft lumen that promotes rapid endothelialisation while limiting SMC and platelet interactions by interfacing electrospun silk grafts with recombinant domain V of human perlecan. Bare electrospun silk grafts endothelialised in a rat model, but neointimal hyperplasia was also observed[1]. Perlecan, which is a major component of the vascular niche, has been shown to promote graft endothelialisation while inhibiting platelet and SMC adhesion[2]. Bioengineered recombinant human perlecan domain V (rDV) exhibits similar cell interactive properties to the full-length endothelial cell perlecan with significantly improved yield[3]. Moreover, the yield of rDV was dramatically improved when the cell culture was maintained at confluency in high glucose containing medium in comparison with the standard cell culture routine, as determined by ELISA. rDV-coated surfaces promoted rapid endothelial cell adhesion and proliferation similar to that on the positive control, fibronectin. Furthermore, rDV promoted endothelial cell capillary-like network formation in endothelial adhesion assay and cell migration in a 3D endothelial cell sprouting assay, indicating the ability of rDV to promote angiogenesis in vitro. Overall, these results demonstrate the potential of rDV as a biomimetic surface coating for enhanced vascular graft performance.**

**2. Microwave Irradiation Assisted Synthesis And Characterization Of Silver-Incorporated Hydroxyapatite Nanoparticle With Antibacterial Properties**

**Mohd Faiz Mohd Yusoff[1], Zamri Radzi[1] , Noor Hayaty Abu Kasim[1]**

1. *Faculty of Dentistry, University of Malaya, Kuala Lumpur, Wilayah Persekutuan, Kuala Lumpur, Malaysia*

**Hydroxyapatite (HA) has been well studied as an osteogenic enhancing implant material. The limitation however remains, its lack of antibacterial property. Incorporation of antibacterial agent such as silver (Ag) into HA structure is considered to be a potentially good strategy to reduce the incidence of peri-implant infections. Therefore, in this study microwave assisted wet-precipitation method was used to produce Ag-HA nanoparticles with different Ag concentrations (HA, 3Ag-HA, 6Ag-HA and 9Ag-HA). The synthesized nanoparticles were then subjected to several physical characterization analyses; XRD, FTIR, XPS, FESEM, HR-TEM, BET, and water contact angle measurement. The antibacterial activity of the nanoparticles were evaluated against Staphylococcus aureus and Streptococcus mitis. The results revealed that the synthesized nanoparticles were composed of Ag and HA. The crystallinity degree of Ag-HA was decreased while the hydrophilicity was increased, linearly to the increment of Ag concentration. The Ag-HA nanoparticles were found to be highly effective against both bacteria in a concentration dependent manner. It can be concluded that the presence of Ag into HA affected the chemical composition of HA and restrain bacterial proliferation that will be useful for medical devices applications.**

## Start Up, Getting To Market & Regulation

**1. Intellectual Property (IP) Tips for Medtech Startups**

**Anthony J Cowle [1], Dan Berger [1]**

1. *Halfords IP, Sydney, New South Wales, Australia*

**Intellectual Property (IP) is one of the most important considerations for a successful Start-Up.**

**Start-Ups need to juggle all sorts of competing tasks when developing a new product, including hiring new employees, raising capital, dealing with regulatory processes, etc. However, the IP of a Start-Up, which can often be the most valuable asset, is often neglected. Proper protection of the IP can be essential to obtaining funding, stopping competitors from copying the product, and, ultimately, the Start-Up being successful.**

**This presentation will detail 10 practical tips for Medtech Start-Ups. This will include how to find and search IP information at the outset to guide the best commercial direction to follow after conception of an 'idea', how to determine whether the idea**

**is capable of Patent, Registered Design or another form of IP protection, when the various forms of IP protection should best be filed, what these forms of IP protection will and won't actually protect, who owns what when employees or consultants are engaged, and, what details can be disclosed and when it is safe to disclose these details.**

**Also covered will be how IP should be used as a 'strategic tool' to maximise long term success in progressing from the local to the global marketplace utilising appropriate licensing and commercialisation strategies.**

## Biomechanics & Computational Bioengineering

**1. Design And Implementation Of An Augmented Reality Game To Diagnose Autism**

**Ahmed A Ahmed, Mohammad[1] Wedyan [1] , Adel Al-Jumaily [1]**

1. *University of Technology, Sydney, New South Wales, Australia*

**The diagnosis of autism spectrum disorder at the beginning of children's life increases the chance for better treatment outcomes. Many researchers are looking for new symptoms or signs that can help to diagnose this disorder in earlier stage. One of these promising signs which can be used, is the upper limb movements tracking. This study aims to diagnosis children with autism in earlier stage by measuring their Upper limb movements based on Augmented Reality (AR) system. The AR system works based on adding of a digital object into the real environment in the real-time to supply the actual world with illustrations or interactive objects. Using AR to create a virtual object (e.g., ball), to encourage the children to move their hands, using the latest trends on Human-Computer Interaction (HCI). Then record their movements using powerful and low-cost solution which is Microsoft Kinect sensor (Kinect). Thus, the proposed system starts from providing a customizable platform for autistic children by designing a game that controls through children hand movements and record the movements data. the he recorded by will be analysed with machine learning using Support Vector Machine (SVM) and Extreme Learning Machine (ELM) to early diagnosing of autism. The proposed system considered HCI system in a friendly environment and cheap and effective cost. The proposed system has been validated in many ways to ensure the accuracy of recorded information. Finally, the system will be applied to accurately discriminate 15 children with autism from 15 typically developing children by using kinematic analysis of a simple task.**

**2.Subchondral Bone Tissue Strain Distribution Under High-Rate Compression: A Combined Experimental And Computational Study**

**Fatemeh Malekipour [1] , Chris R Whitton [1] , peter VS lee [1]**

1. *The University of Melbourne, Parkville, Victoria, Australia*

**Introduction**

**Excessive joint surface load results in microdamage initiation in the subchondral bone (SCB), which may lead to osteoarthritis or bone fracture. The spatial distribution of SCB strain resulting from joint load plays an important role in regulating SCB adaptation. We aimed to estimate the spatial distribution of SCB strain from a joint surface pressure of 30MPa at 5Hz using µCT-based finite element (FE) modelling of cartilage-bone.**

**Methods**

**Osteochondral plugs (Ø=6.5mm, length=10mm) extracted from the third metacarpal condyles of n=8 Thoroughbred racehorses were imaged by µCT (Scanco µCT 50, 40 µm voxel size) to measure BMD and develop a mesh volume (Simpleware, UK), tested in unconfined compression (Instron) perpendicular to the cartilage surface (2.3% strain at 46% strain/s) to measure the stiffness of SCB. Unconfined and confined, quasi-static compression was simulated in ABAQUS to calibrate and measure the in-situ strain within the bone, respectively. Cartilage was simulated as an incompressible, neo-Hookean hyperelastic material (v=0.4999, G=40MPa). SCB elastic modulus was estimated as a relationship between bone mineral density (BMD) and its experimental stiffness. The elastic modulus of each finite element was then estimated from its BMD to develop inhomogeneous FE models.**

**Results and Discussion**

**Unconfined compression analyses reproduced the experimental results. The highest strains occurred within the subchondral bone beneath cartilage which corresponds to the area of fatigue-induced microdamage in racehorses. An important outcome of this study was the estimation of spatial distribution of strain within bone, which is an essential input to mathematical models of bone remodelling.**

**3. Multiphysics Finite Element Modelling Of Heart Function**

**Socrates Dokos[1] , Azam Ahmad Bakir[1] , Yousef Alharbi[1] , Amr Al Abed [1] , James Otton [2] , Nigel H Lovell[1]**

1. *University of New South Wales, Sydney, Kensington, New South Wales, Australia*
2. *Cardiology, St Vincent's Private Hospital, Sydney, New South Wales, Australia*

**Computational simulations of organ function can provide insights into mechanisms underlying pathological function and their possible treatment. We developed a multiphysics model of heart function, implemented using COMSOL Multiphysics finite element software, comprised of coupled excitation-contraction formulations, hyperelastic myocardial passive mechanics, as well as a fluid dynamics blood flow implementation in an idealised left ventricular structure. Incompressible Navier-Stokes formulations were implemented to simulate blood flow within the ventricular cavity, and microstructural muscle fibre orientation was incorporated to mimic the anisotropic properties of the heart. We coupled the ventricular model to zero-dimensional valve equations governing the opening states of the aortic outlet and mitral inlet. These valves in turn were connected to a simple closed-loop Windkessel circuit, including a representation of contracting left atrium. The resulting model was used to simulate healthy normal ventricle as well as aortic regurgitation. The model was successful in simulating healthy pressure-volume (PV) loops, torsional ventricular motion and diastolic blood vortices. Opening and closing of the valves coincided with systolic and diastolic phases, suggesting correct coupling between myocardial and valve models. In the case of aortic regurgitation, backward blood flow influenced the PV loop shape in addition to blood vortices. In summary, by expanding our original ventricular model to include simple valve mechanics, simulations of coupled valve and heart function could be performed.**

1. A. A, Bakir, A. Al Abed, N. H. Lovell and S. Dokos (2017). A generic cardiac biventricular fluid-electromechanics model. 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp: 3680 - 3683.
2. Y. Alharbi, N. H. Lovell, J. Otton, D. Muller, A. Al Abed and S. Dokos (2017). Image-based fluid dynamics analysis of left ventricle outflow tract pressure gradient after deployment transcatheter mitral valve. 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp: 4223 - 4226.

## Emerging Biomedical Technology

### 1. MR Screening: The New Paradigm "The BMDH Concept"

**James Nol[1], Andrew Jones[1]**

1. *Western Sydney University - Blacktown Campus, Blacktown, New South Wales, Australia*

**Computed Tomography "CT" is known to miss majority of Brain strokes (1) and have lower sensitivity than MRI for Brain, Spine, Musculoskeletal and any other soft tissue specifically requested organ. So why do we insist on using the technology, exposing patients to ionising radiation? For the last forty years the use of CT has increased dramatically. In the US the use of CT have risen from less than 3 million a year in 1980 to currently being more than 80 million a year. In 2017, Medicare Australia paid for 3 million CT examinations. Since the 1980's CT technology went through a phenomenal progress with Image quality and excelled to become the golden diagnostic tool in medicine. Unfortunately that came with a heavy price causing mutagenic impact on patients due to the use of ionising radiation. One from every 2000 patients exposed to ionising radiation (2) will face the risk of dying from cancer as well as causing chronic disease and neurological and immune system disorders. An Australian study (3) that looked at more than 680000 people who had CT scans (19 years old and younger) compared with some 10 million (of the same age bracket) who did not have a CT scan had a 24 percent increased cancer prevalence. We need our diagnostic tools; if Ionising Radiation is not the answer where do we go from here?**
**The solution is MR Screening with no contrast agent to move from the 1980 paradigm where CT was the golden to MR screening taking over as the "2020 PARADIGM" employing patient friendly Multiposition MRI equipment. In our 1-year study we have done 1 sequence Diffusion-weighted imaging (DWI) for each of our 549 patients referred to CT scan to rule out a brain stroke. Not surprisingly CT detected 7.5 percent of the strokes with additional 8.8% being suspicious where MRI accuracy was 97.5%, with the 2 patients were suspicious and were subjected to further clinical diagnosis, where if CT was employed without the DWI, 112 patients would've been sent home with a stroke.**

1.Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians Mathews JD, Forsythe AV, Brady Z, et al. British Medical Journal 2013 May 21; 346:f2360
2. http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/MedicalImaging/MedicalX-Rays/ucm115329.htm Webpage verified 12 May 2017
3. https://www.aan.com/PressRoom/Home/PressRelease/849

# A Toolkit For Biomedical Engineering Practitioners In The Disruptive World

**1. Health Technology Management Through Collaboration**

**Ashrith Kumar[1]**

1. *Clinical Engineering , Melbourne Health , Melbourne , Victoria, Australia*

**In the ever changing field of Health Technology we are still not effectively using the opportunity to collaborate and the benefits it presents nationally and internationally at the Clinical Engineering Department level. Opportunity presented is enormous. The risk we face as the Technology changes can be averted solely with the collaborations and knowledge sharing arrangements Example: Cybersecurity, Contaminated Medical Devices Infection risks, cleaning agents affecting the medical devices.**

**Effective collaboration and knowledge sharing in the Hospital Based Clinical Engineering departments would enable a methodology for quicker problem solving. This would enhance the capability of the Clinical Engineering Departments and would effectively reduce the operational budget.**

**Initializing these collaborations from a bottom up approach, where the Biomedical Engineers initiates and involves in this process rather than the top management. Engaging the Biomedical Engineers in these Initiatives would have several benefits to the organisation and also would enable staff to develop skills which are essential for success in their careers.**

**Domestic and international Clinical engineering collaboration specific to Asset Management, Equipment Selection and cyber-security would enable for a formation of a stronger Clinical Engineering community. My research and engagement with University hospital in Geneva (HUG) demonstrated the eagerness to have this type of engagement.**

**This type of collaboration would also benefit the local medical equipment manufacturers in understanding the international market and could provide a tool for the Hospital based Clinical engineering department to be involved with the manufacturers on developing products.**

**2. Paperless Inspection Tools Revolutionising Biomedical Equipment Inspection**

**Naaman Shibi [1]**

1. *Techs4biz Australia, Hawthorn, Victoria, Australia*

**Biomedical tools and equipment represent the forefront of medical technology and cutting-edge science. With increasing industry and governmental regulation, alongside more extensive use of equipment with treatment, the pressure for top maintenance and monitoring has never been greater. Paperless inspection tools and applications represent a dynamic and adaptable way of ensuring everything meets compliance and performs optimally.**

**Where paper-based inspection and asset management solutions are restricted and dated, digital applications are both versatile and future-proof. Improper utilisation of assets and reporting can often decrease return on investment and undermine medical equipment quality assurance. Digital checklists and asset management applications are helping maintain schedules and organise records for both preventative maintenance and for all stakeholders. Corrective actions can be electronically suggested based on custom triggers, ensuring equipment always meets standards and regulations. Small equipment issues can be treated before they become large problems, hazards can be identified for precautionary measures and suitable replacements can be found quicker. With modern paperless solutions, medical technology and tools can spend less time in maintenance or repair stations and more time performing their intended use. Lengthy administrative tasks such as data entry and processing paperwork is removed from the inspection process, allowing in-field technicians and users of the equipment, to get to the next task faster. This is particularly apparent when considering the ease of integration with current and future business systems. Business intelligence, asset management programmes and inspection and reporting applications can all be meshed for one powerful and efficient business ecosystem.**

**3.Risk Based Scheduling For Biomedical Devices**

**Adrian Richards[1] , Glenn Kennett[1]**

1. *SA Biomedical Engineering, North Adelaide, South Australia, Australia*

**AS/NZS 3551 provides well founded guidance on the provision of Clinical Engineering services. SA Biomedical Engineering (SABME) has actively adopted the concept of risk based routine testing programs as outlined in that standard. We are now more than 2 years down this pathway with the rewards starting to show via a program that typically sees wide acceptance within health services to whom services are provided.**

**Given that risk determination is the basis for many day-to-day decisions within healthcare, using the same framework for developing testing protocols and determining schedules for BME testing has been adopted. The intent has been to develop policy in this area and apply it state-wide to our routine testing activities**

**Approximately 70% of risk assessments have been completed. In the highest risk group has more than 80% completed. Where risk assessments have not been completed, scheduling has been allocated according to old protocols. Challenges faced include gaining buy-in from all operational groups within the service and conflicting advice on the WHS elements of our assessment process.**

**Much of the SABME service is now in the position of having a peer reviewed process that clearly defines what routine testing should be performed. Consideration is being given to making the outcomes of the risk assessments undertaken available to any other public health service within Australia that may be committed to adopting this structured approach to their testing activities.**

## Innovations and Best Practices in Biomedical Engineering Education

**1. BioDesign Innovation Melbourne**

**David B Grayden[1] , Michael R Vitale [2] , Kwang Lim [2]**

1. *The University of Melbourne, Parkville, Victoria, Australia*
2. *Melbourne Business School, Carlton, Victoria, Australia*

**In 2016, the Melbourne School of Engineering and the Melbourne Business School established BioDesign Innovation, modelled on courses by Stanford and Hebrew University of Jerusalem. The course teaches engineering and business students to innovate in the Medical Technology (Medtech) space. The course runs over two semesters in which students observe clinical practice to find unmet needs, develop concepts to meet a need, and create a prototype and business plan. We invite speakers from established firms, start-ups, investors, and hospitals to present to the classes. A key feature is that we extensively collaborate with partners within the Australian MedTech ecosystem. A testament to the success of this approach is that seven companies have formed that are actively commercialising devices from the nine teams who participated in 2016 and 2017.**

**This presentation will provide an overview of the course. In the initial weeks of the course, teams are formed and then focus upon articulating unresolved medical problems. Our BioDesign teams typically identify between 30 and 120 unmet needs, demonstrating the huge scope for Medtech innovation. Their next task is to narrow down the needs to the ones that meet the teams' acceptance criteria and have strong commercial potential. The teams then brainstorm engineering concepts to meet the needs. Each team proposes an initial business model to demonstrate potential for commercialisation. Finally, the team builds a prototype and develops a more complete business plan to explore market size and potential, revenue and cost, patent protection, and regulatory requirements.**

**2. Teaching Team Building In Clinical Engineering**

**Paul Junor[1], David Smith[1]**

1. *Sessional Lecturer, Biomedical Engineering, Melbourne School of Engineering, University of Melbourne, Melbourne, Victoria, Australia*
2. *Director, Medigraf Graphics & Engineering Pty. Ltd., Malvern, Victoria, Australia*

**The clinical engineer is a key project manager in the implementation of new medical equipment in clinical practice. There are many examples of the clinical engineer being responsible for major installations and development in new and existing hospitals- Royal Children's Hospital and the Victorian Comprehensive Cancer Centre in Melbourne are two such examples.**

**No project can be successful without a group approach. This paper examines some of the requirements for a successful team effort and the characteristics of the constituents of the team. Then we will address some methods for teaching team dynamics and practice which can be part of the undergraduate and post-graduate phases of the clinical engineer's training.**

**There are many theories advanced as to why teams are successful but the hypothesis by Adair1 that team leaders are trained not born is significant. Belbin2 studied team dynamics to discover the significance of the various roles of team members and the importance of diversity. Tuckman3 looked at how teams form and the various stages that the members go through to achieve a successful joint endeavour.**

**The importance of creative thought, practical application, strong interaction and communication will be discussed and its relevance the clinical engineering practice.**

**Two contrasting examples of team activity will be given.**

**A suggested team building exercise will be documented as a takeaway from this presentation.**


1. Adair, John. The Inspirational Leader, 1st edition, Kogan Page; 2009
2. Belbin, R. Meredith., Team Roles at Work, Second edition, Routledge, 2010
3. Tuckman, Bruce W. Developmental sequence in small groups; Psychological Bulletin. 63 (6): 384–399 1965


## Rehabilitation Engineering

**1. A 3D-printed Soft Robotic Hand Prosthesis: UoW Prosthetic Hand**


**Hao Zhou[1] , Rahim Mutlu[1] , Gursel Alici [1]**

1. *University of Wollongong, Wollongong, New South Wales, Australia*


**A conventional robotic hand prosthesis which requires an assembly of rigid parts (e.g., links and joints) usually lacks inherent mechanical compliance in its topology. This work aims to bring a new dimension to the development of transradial prosthetic hands by employing the concepts of soft robotics and 3D printing, which are enabling technologies to establish functional and affordable robotic prosthetic hands. The mechanical design of a soft prosthetic hand is performed with 3D computer-aided design (CAD) software and its monolithic structure is efficiently fabricated using 3D printing. Without the need of assembly, the fabrication is much more cost-effective than that of those conventional prosthetic hands. With the intrinsic compliance of its soft body, this prosthetic hand, University of Wollongong (UoW) hand, performs satisfactorily in terms of adapting to different surfaces for prehension of objects without reliance on position/motion sensors. Multiple surface electromyography (EMG) sensors together with an efficient gesture-recognition algorithm are utilized to detect muscle activities of a residual limb and provide wireless myoelectric control to the robotic prosthetic hand. The final outcome of this project is a 3D-printed multi-digit robotic hand prosthesis with an efficient control system, programmable mechanical compliance, integrated sensors for tactile feedback, and a neural interface system. In addition to the live demonstration of the UoW prosthetic hand, short video-footages showing the operation and performance of the UoW hand will be shown to support this presentation.**

**2. EMG-Based Robot-Assisted Stroke Rehabilitation For Upper-limb Impairment**


**Kairui Guo [1] , Rifai Chai[2] , Rong Song[3] , Hung Nguyen[2] , Joanne Tipper[1] , Steven Su[1]**

1. *University of Technology, Sydney, Ultimo, New South Wales, Australia*
2. *Swinburne University of Technology, Hawthorn, Victoria, Australia*
3. *Sun Yat-Sen University, Guangzhou, Guangdong, China*


**Stroke is one of the leading causes of disability in all industrialised countries. Stroke survivors can suffer several neurological deficits or impairments; moreover, after completing standard rehabilitation, approximately 50%-60% of stroke patients still experience some degree of motor impairment, and they are at least partly dependent in activities-of-daily-living. Therefore, long-term rehabilitation training is required for stroke survivors. This research project provides an adaptive upper limb assistant robot based on electromyograph (EMG) signal analysis while the stroke survivors are performing rehabilitation exercises. The comparison between the paretic side and non-paretic side offers a powerful tool to design a transformational algorithm. As the goal is to provide assistance, the most effective strategy is to control the paretic arm to mimic the same routine as the non-paretic arm. The paretic arm muscle group will be treated as the abnormal system, and the non-paretic muscle group will be considered as the reference. The health side analysis discovers the interconnection of the eight muscles (biceps brachii, anterior deltoid, posterior deltoid, flexor carpi radialis, extensor carpi radialis, flexor digitorum superficialis and extensor digitorum communis) located on the upper extremity. The necessary support is then provided to the damaged arm based on the transfer function that is developed using permutation algorithm to transform the abnormal system into the reference. Therefore, this rehabilitation robot solves the traditional rehabilitation issues such as requiring a large amount of professional human power and discomfort caused by pre-programmed movement support.**

## Biosensors I

**1. Skin-On-Chip Model A Novel Approach To Study Wound Healing**

**Sahar Biglari[1] , Loan Le[1] , Richard Tan [2] , Steven Wise[2] , Alessandro Zambon[3] , Gaia Codolo[3] , Marina DeBernard[3] , Majid Warkiani[4] , Sina Naficy[1] , Fariba Dehghani[1]**

1. *University of Sydney, Darlington, New South Wales, Australia*
2. *Heart Research Institute , Sydney New South Wales, Australia*
3. *University of Padova, Padova, Italy*
4. *University Technology of Sydney, Sydney, New South Wales, Australia*

**Organ-on-chips are an emergent technology that enables the high throughput screening of bioactive molecules and drugs. Our goal was to develop a skin-on-chip model for wound modelling and testing of transdermal drugs on wound healing mechanism. A 3D in vitro skin model was manufactured by integrating microfluidics and skin cell culture methods to generate a natural microenvironment that facilitated production of cytokines and growth factors. This microfluidic device allowed the culturing of multiple human cell types including human umbilical vein endothelial cells (HUVECs), fibroblasts, and macrophages; these all have pivotal roles in wound healing. The device functioned according to the desired parameters and supported cell growth and was subsequently used to model would healing. The inflammatory cytokines produced by macrophages were quantified by flow cytometer and vascularization was visualized by immunostaining. Consistent with other prior wound healing models, macrophages produced IL-6 and IL-1β as pro-inflammatory cytokines whereas higher accumulation of IL-8 as a pro-angiogenic promoter was measured in presence of M2 macrophages. Next, as a proof-of-concept, we have used this system to model an inflammatory skin response and treatment with Dexamethasone as an exemplary anti-inflammatory drug. In summary, this skin-on-chip system can be used to adequately model the biology of inflammation and has a potential for screening of pro-inflammatory and anti-inflammatory compounds.**

**2. Development of Nanosensors for Monitoring of Reactive Oxygen Species (ROS) in Irradiation Cancer Treatment**

**Jagjit Kaur[1], Guo Jun Liu[2] , Ryan Middleton[2] , Guozhen Liu[1]**

1. *University of New South Wales, Kensington, New South Wales, Australia*
2. *Australian Nuclear Science and Technology Organisation, Sydney, New South Wales, Australia*

**Reactive oxygen species or ROS play an important role in physiological processes but increased concentration of ROS in cells leads to oxidative stress i.e. oxidation of lipids or proteins, nucleic acid damage, programmed cell death and inhibition of enzymes and propagation of diseases like diabetes, cardiovascular atherosclerosis, cancer and neurodegeneration. Therefore, it is very important to detect the ROS levels. In our present study we will develop selective, reliable and robust turn-on fluorescent nanosensor for detection of ROS in real-time. The silica nanoparticles will be modified with superoxide dismutase (SOD) and dihydroethidium (DHE). When superoxide ions are reduced to oxygen and hydrogen peroxide in the presence SOD, DHE produces bright red fluorescence which can be detected by emission spectra at different wavelengths specific for each species. However, in the absence of ROS there will be no fluorescence. Finally, nanosensors will be used for detection of ROS intracellularly in cancerous cells and in vivo to study effect of irradiation cancer treatment on ROS production.**

**Keywords: Reactive oxygen species, nanosensors, silica nanoparticles, turn-on fluorescence, superoxide dismutase enzyme**

**3. A Low Cost Surface Plasmon Resonance (SPR) Device For DIY Science**

**Siddharth Doshi [1] , Chong Yew Chang [1]**

1. *Michael Crouch Innovation Centre, University of New South Wales, Sydney, New South Wales, Australia*

**Surface plasmon resonance (SPR) has been widely used to robustly transduce binding events occurring at a surface by detecting changes in local refractive index associated with binding. For**

**example, SPR can used to detect interactions between biomolecules, leading to applications including the detection of target viral RNA or proteins, or applications in environmental monitoring. However, commercially available systems utilising SPR generally cost $50,000-$500,000, and require expensive consumables. This is inaccessible for scientists in a range of settings, including but not limited to scientists in developing countries.**

**We are reporting the development of a low cost SPR device which can be fabricated for less than $200AUD, using simple optics and open source hardware. An opto-mechanical set-up was designed and 3D printed and integrated with a Raspberry Pi and PiCam for computation and sensing, along with a 5mW 632nm laser pointer, polariser and a single lens and prism as optical components. Glass coverslips deposited with 50nm of gold were used for coupling to surface plasmon modes. The device was the size of a small lunchbox and could detect the intensity dip associated with surface plasmon resonance, and the shift in the dip upon a change in refractive index near the coverslip surface.**

**This device could be used as a teaching tool for principles associated with optical biosensors and also lead to a do-it-yourself (DIY) scientific device used for research in limited resource settings.**

## Medical Device Connectivity

**1. Challenges Of Managing Biomedical ICT Systems**

**Mark Lockwood [1]**

1. *SA Health, Adelaide, South Australia, Australia*

**As biomedical technology changes biomedical engineers must change to keep pace. Today we are with faced with IT challenges; biomedical devices are integrated with computing hardware and corporate ICT networks. The percentage of biomedical equipment reliant on computer infrastructure is increasing. The new Royal Adelaide Hospital project introduced 150 new biomedical ICT systems. Biomedical engineers are now involved in patching servers and devices and data security.**

**SA Biomedical Engineering (SA BME) has taken a proactive approach to leading the development of biomedical ICT system management processes in SA Health. This presentation will cover the work SA BME have done to**

**• Establish a relationship with IT and BME in SA Health**

**• Establish procedures on ICT system documentation, management, security and installations utilising concepts from Information Technology Service Management (ITIL/ITSM) frameworks**

**• Establishing a risk management strategy utilising ISO 80001**

**• Equip staff with skills to support biomedical ICT systems**

**• Project manage biomedical ICT system installations**

**Using biomedical ICT system examples from the new Royal Adelaide Hospital project, some of the challenges this technology presents to biomedical engineers will be presented, along with the skill sets staff need heading into the future.**

**SA BME has taken a lead role in the management of medical ICT systems. SA BME recognised that biomedical equipment has a significant dependence on IT technology and will continue to in the future. SA BME is changing the way IT and biomedical departments work together, to successfully manage this technology, now and into the future.**

**2. RS232 And Beyond - The Journey Of Integration and Connectivity**

**Ian Craig [1]**

1. *Sydney Children's Hospital Network, Westmead, New South Wales, Australia*

**The patient record has always been the 'bible' of the patient's journey through the health system and a common source of patient harm has been errors in transcription, misidentification and inaccuracies in the patient notes. As a way to reduce these sources of errors, integration of medical devices to other devices and the medical record has been a long term aspiration of the medical profession as a whole.**
**This presentation tracks the journey from simple data output from selected devices all the way through to automatic charting, closed loop medication systems and decision support platforms. It looks at case studies of successes, adverse events and unanticipated complications of taking the patient data and connecting it to new destinations. As a general theme, integration is the future of medicine, and there are some key themes to be aware of in connecting a medical device into a system and what the role of an engineer is in ensuring it is done correctly, safely and in a sustainable way.**
**In the evolving concepts of cyber security and the internet of things, this is a time of transition in health care as we go from the standalone nature of medical devices to the concept of a fully integrated end to end medical "system". It is also a time of transition for our profession in the hospital environment.**
**Health Care Industry Cybersecurity Task Force. (2017). Report on improving cybersecurity in the health care industry. Washington, DC: US Department of Health & Human Services.**
**Williams, P. A., & Woodward, A. J. (2015). Cybersecurity vulnerabilities in medical devices: a complex environment and multifaceted problem. Medical Devices (Auckland, NZ), 305-316.**
**Wirth, A. (May/June 2017). Responding to Ever-Evolving Threats. Biomedical Instrumentation & Technology, 269-273.**

## Biosensors II

**1. A Smart "E-Nose" System For Indoor Hazardous Air Monitoring**

**Yujiao Wu[1]**

1. *University Of Technology Sydney, New South Wales, Australia*

**This paper presents a smart "E-Nose" device to monitor the indoor hazardous air. The indoor hazardous odour is a threaten for seniors, infants, children, pregnant women, disabled residents, and patients. To overcome the limitations of using the existing non-intelligent, slow-responding and deficient gas sensors, we proposed a novel artificial-intelligent Multiple Hazard Gas Detector (MHGD) system that is mounted on a motor vehicle-based robot and can be remotely controlled. MHGD is designed to recognize high-risk gases using a self-configured parameter calibration technique. A GA-KNN based machine learning method is proposed based on a gas sensor array. Furthermore, the system is capable to detect and monitor food deterioration and prevent potential risks from diarrhoea, intestinal infections, and amoebiasis due to spoiled food. We have demonstrated through experiments that the odours from spoiled rotten meat, cigarette smoke and the inflammable ethanol can be successful detected and discriminated with the accuracy of 92.5%.**

**2. Embroidered Electrodes For Bioelectrical Impedance Analysis: Impact Of Contact Surface Area And Stitch Type**

**Irini Logothetis[1], Ignacio Gil[2], Raul Fernandez-Garcia[2], Elena Pirogova[1], Peter Dabnichki[1], Olga Troynikov[1]**

1. *RMIT University, Melbourne, Victoria, Australia*
2. *Polytechnic University of Catalonia, Terrassa*

**Measuring electrical activity in the human body is vital in the diagnosis and monitoring of patients; thus, much attention needs to be provided to the design of electrodes. Currently these medical devices are mainly used in clinical settings with clinical electrodes; however, with the development of flexible and stretchable electronics such systems can be incorporated into attire connected to textile electrodes that can be worn by the patient in home settings. Consequently, research into efficient textile electrodes is essential. To identify efficient embroidered electrodes for bioelectrical impedance analysis (BIA), we initially studied the electrodes in a dry and wet state followed by the influence of common parameters, such as size and stitch type. This paper presents the influence of these parameters on the resistance and reactance of the electrodes, thus identifying the ideal parameters for the electrodes resulting in the lowest impedance. For dry electrodes, we observed specific relationships between the parameters and impedance identifying that lower impedance is recorded with an increased contact area. Wet electrodes displayed irregular results and thus it can be concluded that they could potentially impair BIA measurements. In conclusion, embroidered electrodes can be incorporated into BIA systems for long term health monitoring in home settings.**