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Lecture #1: Designing and micro/nano-fabricating portable impedance-based point-of-care biosensors

Companion diagnostics are central to the success of personalized medicine. The portable glucose sensor is indeed the most successful example of a companion diagnostic device. They are used by millions of diabetics worldwide to monitor their health and help make decisions about their medication usage. Building from this example, the lecturer will present the power of metabolomics to develop a collection of multiplexed companion diagnostic systems on a unified platform that can be used to diagnose, monitor, or predict multiple diseases. Metabolomics is an emerging field of "omics" science. Metabolites are very sensitive to gene-environments or gene-pathogen interactions. In this talk, the lecturer will discuss their impedance-based biosensor design to measure not just one metabolite, but dozens or even hundreds at a time from human body fluids (such as blood, urine). The testing time is within 10 minutes at the cost of $1 US Dollar per metabolite test. The sensor is also able to detect metabolites at the concentration of nM. To avoid "false positive", a competitive assay design was applied. Such a platform technology can be easily extended for environmental monitoring, food-safety checking, cancer screening and infectious disease diagnosing.

Lecture #2: Developing pulsed wave instruments for renewable biofuel and therapeutic applications

Wireless power transmission is on the rise for a variety of applications from electric vehicles to smartphone and implantable microelectronic devices (IMD). Unlike pacemakers, extreme size constraints and high power consumption prevent many IMDs such as cochlear and retinal implants from using primary batteries as their energy source. Moreover, such devices need to deliver a sizable volume of information from external artificial sensors to the nervous system while interfacing with large neural populations at high stimulus rates. Nonetheless, the skin barrier should remain intact and the temperature should be maintained well within the safe limits. In this talk I will cover the fundamentals of efficient power and wideband data transmission across inductive links. I will discuss the optimization procedure to achieve the highest possible power transmission efficiency using two, three, and four coil systems. I will review some of the latest techniques to establish wideband bidirectional communication links across the skin, and will also touch on efficient methods to convert the received AC power on the IMD to DC and stabilize it at a desired level despite coupling variations due to coil misalignments.

Tutorial #1: Engineering of Nanobiotechnological Systems

Nanotechnology is a newly developed engineering field, aiming to create nanomaterials ranging 10nm to 100nm in size. Nanotechnology has presented numerous new and exciting applications across many frontiers of innovation. In particular, there are rapidly emerging new innovations in the field of biotechnology and health technology. Innovations in microfluidics, nanoparticles and DNA machinery have frequently being reported. Applications of these technologies are being adapted and applied in uses, which improve upon existing medical technologies (such as more affordable and portable diagnostic testing tools, as well as enhanced medical imaging). Furthermore, applications of these technologies are also being used to create completely new medical technologies (such as nanoparticles for cancer treatments and personalized medicine).

The core of this tutorial, nanobiotechnology, is very multidisciplinary in nature unifying a variety of topics, presented in a cohesive way that can be introduced and understood by electrical engineers. These varied topics include electromagnetics, fluid flow, thermodynamics and microfabrication. Although there are certainly textbooks which cover these topics in great detail, there are none, which integrate these diverse topics together, relate them to relevant topics in nanobiotechnology, or that give a specifically engineering-oriented view on these topics.

Biography

Dr. Jie Chen received his Bachelor degree from Fudan University, China, and his Ph.D. degree from the University of Maryland, USA. He is currently a Professor in the Faculty of Engineering at the University of Alberta, Canada. He is also a research officer at Canadian National Research Council / National Institute for Nanotechology (NINT). Dr. Chen is an IEEE Fellow. He is also a Fellow of the Engineering Institute of Canada. He received the Killam Professorship Award, one of the highest honours to a professor in Canadian Universities, for his outstanding contributions to research, teaching and community service. He has coauthored two books, 81 peer-reviewed journal papers, and 80 peer-reviewed conference proceeding papers. They were published in high impact journals, such as Physical Review Letter (impact factor: 7.728), Journal of Biomedical Nanotechnology (impact factor: 7.578), Small (impact factor: 7.514). According to the Google Scholar (http://scholar.google.ca/citations?hl=en&user=kLA9_-8AAAAJ), his H-index is 26 and i10-index is 56. His total citation is over 3,030. Dr. Chen has received numerous awards such as (i) Distinguished Lecturer of the IEEE Circuits and Systems Society; (ii) Best student paper award at IEEE/National Institutes for Health (NIH) 2007 Life Science Systems & Applications Workshop. (iii) Best Poster Award, the Conference of Biology and Synchrotron Radiation (BSR), International Union of Crystallography, Hamburg/Germany, 2013. (iv) His research on designing miniaturized pulsed wave device for intra-oral dental tissue formation was listed by “Reader’s Digest” as a major medical breakthrough in Canada in the year of 2006. He has trained 68 HQPs including 4 postdoc fellows, 18 Ph.D., and 15 M.Sc. Among the HQPs, one becomes an assistant professor at Johns Hopkins University, two entered Stanford University, one entered Yale Medical School. He also has 7 patents, and most are either in commercial use or are licensed by the other companies. He has nearly 15 years of project, administrative and management experience and has successfully helped found two spin-off companies. One was acquired by QUALCOMM in 2005, and the other produces digital HD-radios installed in most brands of automobiles and sold in Walmart and BestBuy. Since 2000 he has directed various research and business teams ranging in size from 3 to 20 members. Dr. Chen is currently the Program Leader for a NINT Program. He previously led two Alberta Health Service Projects from 2010-2012 (worth $1.1M) and has also been involved in several other multi-million dollar projects as a co-PI, such as a recent Alberta Innovates Bio-solution $5M project. Over the past 5 years he has spun off a UofA biotech company, which focuses on the pulsed wave technology for dental tissue formation and the product passed clinical phase 2 trials. The product is approved to sell worldwide. He has also organized or chaired many national and international conferences / symposiums / workshops ranging in size from 50 to 1000 participants.

His current research includes:
(i) Designing portable impedance-based point-of-care devices for detecting metabolic biomarkers, monitoring environmental toxins, sensing plant infections at an early stage, and screening pathogens for food safety.
(ii) Developing a pulsed-wave technology platform to stimulate cell growth (with applications in cell therapy, tissue engineering, mental health, and antibody production), and microorganism growth (with applications in increasing renewable biofuel/algal oil, antibiotics, omega-3, and wine/beverage production) and waste water treatment.
(iii) Using the Markov Random Field to design ultra low-power fault-tolerant nanoscale circuits.