SCHOOL OF ENGINEERING

DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING 化學及生物工程學系

School of Engineering Distinguished Workshop: *The Future of Health Technology in Modern Medicine*

The Hong Kong University of Science and Technology

Date: 3 June 2024 (Monday)

ABSTRACT

Biosensor and Device

Tear Glucose Analysis Using a Smart Contact Lens

Prof. Jang-Ung PARK

Yonsei University

Abstract

With the development of a healthcare system, studies regarding the diagnosis of diabetes non-invasively by monitoring the glucose level in various body fluids such as tear, saliva and ISF are ongoing. Among them, tear is emerging as the one of the most promising body fluids for monitoring health conditions and many studies are underway to measure the tear glucose level through various biomedical platforms including contact lenses. For these platforms to be reliable for diagnosing diabetes, it is essential to clarify the correlation between blood glucose and tear glucose which remains controversial. To address this controversial issue, studies that present the relationship between blood glucose and tear glucose using smart contact lens were reported. However, previous smart contact lenses were operated only at specified time which is non-continuous and have failed to identify the exact correlation. Herein, we present an in-depth investigation of the correlation between blood glucose and tear glucose. Our smart contact lenses are capable of continuous and long-term measurements at short time intervals which enables exact comparative analysis. The developed smart contact lenses were applied to normal and diabetic animal models for authentic clinical investigation of the correlation between blood glucose and tear glucose. This approach can offer unprecedented prospects for applications of the advanced biomedical platforms in further clinical trials.

Keywords: Contact Lens, Wearable Electronics, Bio-electronics, Glucose, Tear

About the Speaker

Prof. Jang-Ung Park achieved his Ph.D. degree from the University of Illinois at Urbana-Champaign (UIUC) in 2009. After that, he served as postdoctoral fellow at Harvard University from 2009 to 2010. He worked as an assistant / associate professor in School of Materials Science and Engineering at UNIST from 2010 to 2018. He is now a professor in the Department of Materials Science and Engineering at Yonsei University and the Department of Neurosurgery at Yonsei University College of Medicine. He has received awards such as USA CooperVision Science and Technology Award: CooperVision Seedling Award (2013) and USA CooperVision Science and Technology Award: CooperVision Translational Research Award (2014). He dedicates his effort in collaborating with companies such as Samsung Electronics and LG Electronics. His current research is focused on wearable and biomedical electronics.

Chitosan-based Injectable Hydrogels with High-density Dental Stem Cells for Therapeutic Application in Tissue Engineering

Prof. Sangjin LEE

The University of Hong Kong

Abstract

Bioactive molecules such as graphene oxide (GO) incorporated hydrogels have received great attention and have shown excellent potential for use in the field of bone tissue engineering due to their unique osteogenic functionalities. In this study, we developed a GO-incorporated injectable hydrogel system by using glycol chitosan (gC) and oxidized hyaluronic acid (oHA). Through oxidation, aldehyde groups were introduced onto the HA. Blending this with gC allowed for the formation of an aqueous hydrogel matrix. Physico-chemical characterization demonstrated that the gC/oHA/GO hydrogel matrix exhibited robust mechanical properties and stability. The gC/oHA injectable hydrogel could easily modulate the GO content and had robust mechanical properties with improved stability. As an in vitro assessment, GO-incorporated injectable hydrogel exhibited very little toxicity, but showed excellent osteogenic activity. This was confirmed by both in vitro and in vivo assessments. There results showed that GO-incorporated injectable hydrogels enhanced bone tissue regeneration as compared to control injectable hydrogels. Therefore, our results indicate that our injectable hydrogel system could be used for delivering GO. This material may serve as an excellent tissue scaffold for use in treating bone defects. This preliminary study will pave the way for these future investigations.

About the Speaker

Prof. Sangjin Lee graduated with bachelor’s degree in Dental Laboratory Science at Catholic University of Pusan, master’s degree in Maxillofacial Biomedical Engineering and Ph.D. in the Dental Materials in Kyung Hee University (Korea) and worked as Postdoctoral Research Associate in Department of Biomedical Engineering at Case Western Reserve University in 2018 and in Richard & Loan Hill Department of Biomedical Engineering at University of Illinois Chicago in 2019-2022. He is now an Assistant Professor in Applied Oral Sciences & Community Dental Care, Faculty of Dentistry at The University of Hong Kong. He is an expert at Craniofacial Regeneration. He is engaged on a multidisciplinary approach to tissue engineering for the regeneration of damaged organs in the body, which involves the utilization of biomaterials in combination with stem cells and disease treatment tools, such as cancer therapies.

Ultrafast Cardiovascular Ultrasound Imaging

Prof. Wei-Ning LEE

The University of Hong Kong

Abstract

Ultrafast ultrasound is a new way of depicting cardiovascular tissues by ultrasound at a frame rate higher than 1000 frames per second. The high frame rate permits detection of transient physiological phenomena and fast events in the circulatory system, such as electromechanical waves, naturally occurring elastic waves, externally induced shear waves, blood flow, and myocardial and vascular wall motion. Unlike standard echo, ultrafast ultrasound is enabled by sending out non-focused waves to interrogate the full field of view and receiving echoes for subsequent image formation and data analysis at the expense of image quality, including lower signal-to-noise ratio, poorer contrast, and degraded spatial resolution. This hampers the downstream quantitative analysis of mechanics and hemodynamics in the cardiovascular system. This talk will first introduce our coded excitation method in a flexible transmission-reception scheme with a randomized singular-value-decomposition clutter filter. The proposed imaging method involves only linear operations and can significantly improve the signal-to-noise ratio and image contrast of ultrafast ultrasound imaging for quantitative assessment of natural mechanical and hemodynamic behavior of the heart and the artery in clinical settings at 1600 frames/sec in 2D based on 1D array transducers and at 360 volumes/sec in 3D based on a 2D array transducer. This talk will then present the characterization of cardiovascular anisotropy and hyperelasticity based on inherent and remotely induced elastic waves by a standard imaging array probe and briefly introduce our blood flow velocity estimation by Physics-informed Neural Networks.

About the Speaker

Prof. Wei-Ning Lee graduated at National Taiwan University with bachelor's and master's degree in Electrical Engineering. She then graduated at Columbia University with M. Phil. and Ph.D. in Biomedical Engineering. She is then a Postdoctoral Fellow at ESPCI ParisTech in Institut Langevin, Paris, France in 2010-2012. She then joined as an assistant professor with the Department of Electrical and Electronic Engineering and Biomedical Engineering Programme at The University of Hong Kong and is now associate professor with tenure. She won a New Investigator Award at the American Institute of Ultrasound in Medicine (AIUM) Annual Convention in 2009 and received an Early Career Award from the Hong Kong Research Grands Council in 2013 and a Healthy Longevity Catalyst Award (Hong Kong) in 2022. Her current research interests focus on developing functional ultrafast ultrasound imaging methods with neural networks to investigate microstructure, mechanics, and hemodynamics of cardiovascular and musculoskeletal tissues. She currently serves on the Editorial Board of Physics in Medicine and

Biology and the Advisory Editorial Board of Ultrasound in Medicine and Biology, and the Technical Programme Committee of the IEEE International Ultrasonics Symposium and is an Associate Editor of IEEE Transactions on Medical Imaging.

E-skins and Their Applications in Robotics and Healthcare

Prof. Chuanfei GUO

Southern University of Science and Technology

Abstract

E-skins can convert mechanical stimuli to electrical signals, and have been widely used in robot haptics and advanced healthcare. Iontronic sensors present much higher sensitivity and higher signal-to-noise ratio over traditional capacitive sensors because of the atomic scale charge separation at the junction of ionic conductor-electronic conductor, and thus they are an ideal selection for e-skins. In this work, I will discuss the design and applications of flexible pressure sensors or sensor arrays based on iontronic sensing mechanism—by using a soft ionic active material, either an ionic gel or a polyelectrolyte, to form electric double layers with flexible electrodes. We design several device configurations and synthesize new ionic materials for combined high robustness, negligible crosstalk, low drift, and high sensing performances. Robots using such iontronic skins can precisely detect pressure distribution during manipulation tasks without any interfacial failure or signal drift. Furthermore, such iontronic sensors can be applied to the human body to detect many physiological signals for healthcare monitoring.

About the Speaker

Prof. Chuanfei Guo, born in Yongxing, Hunan, is a professor in Materials Science and Engineering at the Southern University of Science and Technology (SUSTech), National Specially-Invitied Expert (Youth Project) and editor of Materials Today Physics and Soft Science. He received his bachelor’s degree on Material Science and Engineering in the Huazhong University of Science and Technology (HUST), 2006. In 2011, he earned a PhD degree on Condensed Matter Physics from the Chinese Academy of Sciences. From 2011 to 2016, Dr. Guo worked as a postdoctoral fellow (research associate) at Boston College and the University of Houston. He joined SUSTech since 2016. He mainly focuses on the high-performance electronic skins, flexible electronic technology for human-body and abnormal micro-nano fabrication technology. Dr. Guo has published over 150 articles in Nature Materials, Nature Communications, PNAS, LSA, JACS, Advanced Materials, Nano Letters, Advanced Functional Materials, Materials Today, ACS Nano, etc.He has applied for more than 50 patents, 28 of which have been granted by China, America, Japan, ect., including 4 USA patents. He participated in establishing one national criterion and one professional standard and editing two English books. His research findings have been widely reported by news media and scientific journals, including New York Times, Xinhuanet, Science Daily, Materials Today, and Physics Today. He achieved the second class prize of Natural Sciences of Beijing. He is heading or participating in the innovative and entrepreneurial team of Talent

Program in Zhujiang of Guangzhou Province, major and general projects of national science funds, Layout program of basic research discipline in Shenzhen, ect.

Ultrahigh-resolution Endoscopic Optical Coherence Tomography for Assessing Tissue Histology *In Vivo*

Prof. Wu YUAN, Scott

The University of Hong Kong

Abstract

Endoscopic OCT (EOCT) affords in vivo high-resolution three-dimensional (3D) microanatomies imaging of internal luminal organs. It has been demonstrated for a wide range of clinical applications, such as disease diagnosis and screening where traditional biopsy suffers from sampling error or risk of complications. Integrating innovations in instrumentation and image processing, ultrahigh-resolution EOCT developed in our laboratory—for the first time—achieves a resolving power approaching that of standard histopathology and enables real-time quantification of tissue's microstructure/optical properties at the microscopic level. This technology has opened exciting new opportunities in GI, pulmonary and brain research for addressing unmet clinical needs in early disease detection, guidance of surgical intervention and monitoring of treatment outcome. Here, I will present our recent progress on pushing the technology envelope of ultrahigh-resolution EOCT, showcase a few representative applications including pre-cancer detection, small airway pathophysiology assessment and intra-operative guidance for neurosurgery, and discuss the ongoing development of this technology with machining learning-based image interpretation and quantification.

About the Speaker

Prof. Wu Yuan joined the Department of Biomedical Engineering in the Chinese University of Hong Kong as an Assistant Professor in 2020. He received his Ph.D. degree in Electronic Engineering from the Chinese University of Hong Kong in 2008. He was a research associate at the Department of Biomedical Engineering, Johns Hopkins University, with a joint appointment to the Department of Neurologic Surgery, Mayo Clinic.

Prof. Yuan research focused on the high-solution biomedical imaging and AI-assisted image processing technologies for translational applications. He has pioneered several innovative bio-photonics imaging probes/devices to enable translational applications of high-resolution optical endomicroscopy imaging, such as portable ultrahigh-resolution endoscopic OCT system, ultracompact OCT microprobe, multifunctional deep-brain microneedle and 3D volumetric airway balloon imaging technology etc. To date, he has published 40 peer-reviewed articles, including Nature Communications and Science Advances, with a total citation about 2000+ and an H-index 24 (according to Google Scholar).

Prof. Yuan currently serves as vice-president of Hong Kong Optical Engineering Society (HKOES). He also serves on the editorial board of several international journals in the area of bioengineering and medicine.

Doctor! I Feel a Breast Mass, What Should I Do?

Dr. Ronald C. K. CHAN

The Chinese University of Hong Kong

Abstract

Modern medicine is made possible from an array of technologies, from diagnostic to therapeutic. Every piece of technology in the loop has been innovated and perfected by decades of engineering effort. Recent AI developments have also found their way to clinical practice.

Let's imagine a patient presenting with breast mass on her course of diagnosis and treatment. What steps will she go through and what technologies are involved? At the end of the day, what do doctors want and expect from novel medical technologies in the AI era?

About the Speaker

Dr Chan is a medical practitioner and a specialist in pathology. He has extensive experiences in digital pathology (DP) and pathology AI developments. He has multiple grants and publications in this area. He is particularly interested in bridging the gap between industry and frontline healthcare workers. He is currently a member of the digital pathology working group in Hospital Authority to drive AI and DP development in the public sector. He also oversees digital pathology related research in CUHK. He had experiences in collaborating with private companies in transfer learning of cervical smear diagnostic systems and was awarded ITF in this project. He also had extensive connections with digital pathology solution vendors, academia and pathology regulatory bodies and frontline pathologists.