Yonsei-Purdue Bioengineering Workshop 2023

July 19, 2023

Department of Electrical & Electronics
Yonsei University

Organized by

Y-Base Institute, Department of Electrical & Electronics, Yonsei University
Center for Strained Engineered Electronic Devices

Program

02:30 – 02:40	**Opening Remark** *Ilgu Yun* (Yonsei EE Department Chair)
	Session 1 Chair : Jong-Hyun Ahn
02:40 – 03:00	**Probing in-vivo Electromagnetic Properties using Magnetic Resonance Imaging** *Dong-Hyun Kim* (Yonsei University)
03:00 – 03:30	**Hyperspectral Learning for Mobile Health Applications** *Young L. Kim* (Purdue University)
03:30 – 03:50	**Computational optical imaging for biomedical applications** *Seung Ah Lee* (Yonsei University)
03:50 – 04:20	**In-sensor computing for artificial vision Wearable Biomedical Devices for Human Healthcare and Beyond** *Chi Hwan Lee* (Purdue University)
04:20 – 04:40	Coffee Break
	Session 2 Chair : Chi Hwan Lee
04:40 – 05:00	**Soft Bio-integrated Electronics for Unconventional Brain-machine Interfaces** *Ki Jun Yu* (Yonsei University)
05:00 – 05:30	**Smart Medical Devices with µSensors and µActuators** *Hyowon (Hugh) Lee* (Purdue University)
05:30 – 05:50	**Hydrogel-Based Biomaterials for Next-Generation Soft Electronics** *Jungmok Seo* (Yonsei University)
05:50	**Closing Remark**

Probing in-vivo Electromagnetic Properties using Magnetic Resonance Imaging

Dong-Hyun Kim, PhD

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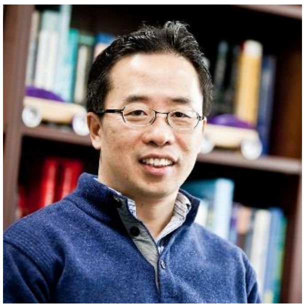
Abstract

The talk, "Probing in-vivo Electromagnetic Properties using Magnetic Resonance Imaging," explores the utilization of MRI, including MR-EPT (Magnetic Resonance Electrical Property Tomography), to investigate the electromagnetic properties of biological tissues. Recent advancements have expanded MRI's capabilities beyond conventional imaging, enabling the non-invasive measurement of tissue conductivity and permittivity. This presentation provides an overview of the principles and techniques involved in MR-EPT. It covers how MR-EPT combines traditional MRI with electromagnetic field modeling to estimate tissue electrical properties. The talk discusses the challenges associated with accurate property mapping, including magnetic field perturbations, hardware considerations, and image reconstruction techniques. Furthermore, the talk highlights the potential applications of MR-EPT in characterizing tissue properties, such as distinguishing healthy and diseased tissues, monitoring treatment responses, and guiding interventions. It also addresses the limitations and ongoing research efforts in improving the accuracy and robustness of MR-EPT. By providing quantitative information about tissue conductivity and permittivity, MR-EPT offers a deeper understanding of tissue function and pathology. The integration of MR-EPT into clinical practice has the potential to revolutionize diagnostics, treatment planning, and personalized medicine, enhancing patient outcomes in diverse medical fields.

Short Biography:



Dr. Donghyun Kim is a professor at Yonsei University's School of Electrical and Electronic Engineering in Seoul, Korea. He heads the Medical Imaging Research Lab and has an extensive background in the field. Dr. Kim completed his B.S. in Electronic Engineering at Yonsei University before pursuing an M.S. and Ph.D. in Electrical Engineering at Stanford University. He also conducted a post-doctoral fellowship at Stanford's Department of Radiology. Dr. Kim has held positions at the University of California, San Francisco, and has been associated with Yonsei University since 2006. He has published numerous articles, with a focus on medical imaging, and is recognized for his contributions to the field. Dr. Kim's expertise and research have advanced medical imaging and contributed to improved diagnostic capabilities.

Footnote: This abstract and biography has been generated with the help of chatGPT.

Hyperspectral Learning for Mobile Health Applications

Young L. Kim

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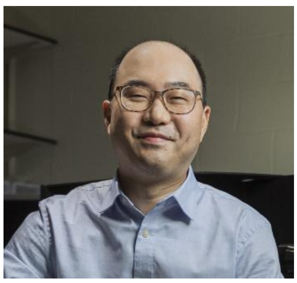
Abstract

My current research area focuses on physics/biology-informed machine learning to address large-scale health challenges. This talk will focus on hyperspectral learning that can recover detailed spectra information from a red-green-blue (RGB) image that can easily be taken using smartphone cameras. Hyperspectral learning exploits the idea that a photograph is more than merely a picture and contains detailed spectral information. To overcome limitations of purely driven machine learning, the domain knowledge about tissue optics and machine vision are further incorporated into learning algorithms to ease the requirement of a large training dataset. In this talk, we will discuss mobile health (mHealth) applications with a focus of hemodynamic parameters, such as blood hemoglobin content and oxygen saturation, for several different diseases and disorders. We will also share ongoing mHealth research in sub-Saharan Africa including Kenya and Rwanda. This approach has reciprocal innovation, allowing mHealth technologies developed in the resource-limited settings to be brought back to the US, as demonstrated in our mHealth surveillance study with Centers for Disease Control and Prevention. Overall, AI powered mHealth technologies can potentially offer mobility, simplicity, and affordability for rapid and scalable adaptation in a variety of digital health applications, including telemedicine.

References

1. PNAS Nexus, 2:pgad111, 2023
2. Nano Letters 21:921, 2021
3. Nature Communications 11:328, 2020
4. Optica 7:563, 2020

Short Biography:



Young Kim is Professor and Associate Head for Research of Weldon School of Biomedical Engineering at Purdue University. He is a scientist at Centers for Disease Control and Prevention. He has affiliations with Purdue Quantum Science and Engineering Institute, Regenstrief Center for Healthcare Engineering, and Purdue Institute for Cancer Research. His current areas of research include data-centric biophotonics and hybridization of physical and digital properties. He has successfully managed an atypically broad spectrum of work ranging from cancer research, machine learning, optical imaging, spectroscopy, biomaterials, metamaterials, to cryptographic primitives. In particular, he is currently working on reciprocal innovation such that mHealth technologies developed in resource-limited settings can be brought back to developed country settings, which was recognized as the First Prize of the NIH Technology Accelerator Challenge 2020. He has also pioneered cyberphysical biomedical security technology development for medicines and pharmaceutical products, supported by the AFOSR Cybersecurity Program. Young Kim received his PhD and MSCI (Master of Science in Clinical Investigation) from Northwestern University and postdoctoral training supported by NIH NCI Cancer Research Careers program.

Computational optical imaging for biomedical applications

Seung Ah Lee

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Abstract

Optical imaging is an essential tool in biomedicine that allows for probing and studying biological systems at the cellular, tissue, and organism levels. Computational imaging allows for imaging beyond the physical limits of conventional optics, and enables the efficient design of imaging systems whose hardware and software can be jointly optimized for specific imaging applications. In this talk, I will describe new microscopes and cameras where algorithms replace bulky and expensive optics, designed and optimized through computational modeling of light propagation in biological tissues and imaging systems. Our computational microscopes enable label-free, quantitative phase imaging of biological specimens with low-cost hardware, with applications in digital pathology and field-diagnostics. Our lensless cameras are optimized for multiplexed and task-specific imaging with ultra-compact and low-cost design. I will also discuss the methodologies used in the design, construction, and image reconstruction of these non-conventional imaging systems and discuss their potential for realizing task-specific smart imaging systems for various biomedical applications.

References

1. Lee et al., Optica, 10(1), 72-80, 2023
2. Kim et al., APL Photonics, 2023, In press
3. Yi et al., Optica, 9(11), 1227-1237, 2022
3. Lee et al., ACS Photonics, 8(5), 1307-1315, 2021

Short Biography:

Seung Ah Lee is an Assistant Professor in Electrical and Electronic Engineering at Yonsei University in Seoul, Republic of Korea. She received her Ph.D. in Electrical Engineering from California Institute of Technology in 2014 and M.S and B.S in Electrical Engineering from Seoul National University. Prior to joining Yonsei University, Dr. Lee worked as a research scientist at Alphabet Inc. and a postdoctoral scholar at Stanford University. Her research interests involve computational imaging and microscopy, low-cost imaging system design and deep-learning for optical imaging. She serves as a chair and committee for numerous conferences including Optica Imaging Congress and the SPIE Photonics West.

Wearable Biomedical Devices for Human Healthcare and Beyond

Chi Hwan Lee, PhD

Leslie A. Geddes Associate Professor of Biomedical Engineering, Mechanical Engineering, and by Courtesy of Materials Engineering and Speech, Language, & Hearing Sciences at Purdue University | Adjunct Professor of Optometry at Indiana University

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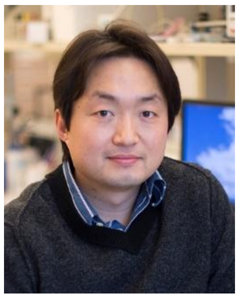
Abstract
My laboratory at Purdue University focuses on bridging the critical gap between engineering and unmet clinical needs through the innovation of wearable technologies. Our scholarly efforts are dedicated to addressing this gap using novel yet simple flexible micro-transducers with a clear path towards translation into measurable clinical impacts. We explore a wide variety of wearable biomedical devices that are safely attachable to the skin or eye, enabling continuous remote assessment of human health and chronic diseases. The potential applications of these devices are far-reaching, from healthcare to rehabilitation and telemedicine. In this talk, I will discuss: (1) Sticktronics - sticker-like thin film electronics that are flexibly attachable to the curved surfaces of arbitrary places, increasing the range of industrial and healthcare applications; (2) sensory skin patches that are tailored for various clinical needs of particular urgency in the telemedicine field; (3) smart contact lenses that are built on various commercial brands of soft contact lenses, which could be used to continuously monitor chronic ocular diseases such as glaucoma; and (4) injectable silicon nanoneedles that are built on flexible, biodegradable patches for painless and long-term sustained ocular drug delivery. I will present the results of detailed experimental and theoretical studies to provide insights into each of these topics.

References
1. Nature Communications, 13:5518 (2022)
2. Science Advances, 8, eabn1772 (2022)
3. Advanced Materials, 34, 9, 2108021 (2022)



Short Biography: Dr. Chi Hwan Lee is the Lesli A. Geddes Associate Professor of Biomedical Engineering and Associate Professor of Mechanical Engineering, and by Courtesy, of Materials Engineering, and Speech, Language, and Hearing Sciences at Purdue University. He obtained his M.S. and Ph.D. degrees in Mechanical Engineering from Stanford University in 2009 and 2013, respectively. Afterward, he completed a postdoctoral training in the Department of Materials Science and Engineering at the University of Illinois at Urbana-Champaign, under the guidance of Professor John A. Rogers. His research focuses on developing wearable devices to address unmet clinical needs and translate them into measurable clinical impacts. For his notable contributions, Dr. Lee has been honored with prestigious awards such as the 2021 Sensors Young Investigator Award, 2020 Purdue CoE Early Career Research Award, 2019 NIH Trailblazer Award, and 2019 Korean-American Scientists and Engineers Association (KSEA) Young Investigator Award. He has published over 70 journal papers and four book chapters, and issued 5 U.S. patents, filed 11 utility patents, and co-founded four startup companies. At Purdue University, he has secured research grants totaling over $35M, of which he has been responsible for more than $10M, from a broad array of governmental and industrial sources.

Soft Bio-integrated Electronics for Unconventional Brain-machine Interfaces

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Abstract

My current research focuses on flexible and stretchable biocompatible electronics in the forms of wearable and implantable platforms. Conventional rigid systems have limitations in forming tissue interfaces due to a Young's modulus mismatch, resulting in poor device capabilities and noise. To overcome these limitations, we have been developing flexible and stretchable electronics with a low modulus to establish intimate contact with the skin, enabling the acquisition of high-quality signals and tissue actuation. Among the various soft bio-integrated electronics that we are developing, in this talk, I will primarily introduce recent advances on soft neural interfaces for unconventional brain-machine interfaces. Specifically, I will discuss our efforts on (1) 3D neural interfaces, (2) mri compatible neural interfaces, (3) space unrestricted optogenetics, and (4) bioresorbable hybrid neural interfaces for diverse applications, including the diagnosis and treatment of disorders, paving the way for the next generation of neuroscience and medical science.

References

1. Science advances 9 (22), eadh1765 (2023)
2. Nature communications 13 (1), 5815 (2022)
3. npj Flexible Electronics 6 (1), 86 (2022)
3. Advanced Materials, 34 (4), 2105865 (2022)

Short Biography: Dr. Ki Jun Yu is an Associate Professor of School of Electrical and Electronic Engineering at Yonsei University. He obtained his B.S., M.S., and Ph.D. degrees in Electrical and Computer Engineering from the University of Illinois at Urbana-Champaign in 2008, 2012, and 2015 respectively under the guidance of Prof. John A. Rogers. Subsequently, he pursued a postdoctoral training in the Department of Materials Science and Engineering at the University of Illinois at Urbana-Champaign, also under the guidance of Professor John A. Rogers. His research primarily focuses on developing soft electronics for biomedical applications. He has published 65 journal papers with an h-index of 41 and has accumulated more than 12,000 citations to date. In recognition of his research accomplishments, he received the Outstanding Achievement Professor Award (Research Category) from Yonsei University in 2023. Since 2019, he has held the position of Hwalchun Distinguished Professor and currently serves in that capacity. Also, he received Distinguished Teaching Awards for five consecutive years (2018~2022) in the School of Electrical and Electronic Engineering as well as the Best Teaching Awards in the entire Engineering Departments for three consecutive years (2018~2020) at Yonsei University.

Smart Medical Devices with µSensors and µActuators

Hyowon (Hugh) Lee

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Abstract
The development of chronically reliable and multifunctional implantable medical devices is an enormous challenge in biomedical engineering with significant economic and clinical implications. Soon after implantation, implants often suffer from substantial performance degradation and premature failures due to various abiotic and biotic failure modes. Enabling technologies that improve the lifetime of these implantable devices can have an enormous impact on many debilitating chronic neurodegenerative diseases that are difficult to diagnose and treat. In this presentation, I will discuss our latest efforts to utilize thin-film-based microscale sensors and actuators to fabricate self-clearing implantable medical devices for chronic disease management. As a proof-of-concept, I will share our efforts to create chronically implantable self-clearing catheters, glaucoma drainage devices, novel peripheral nerve interface, and electrochemical biosensor arrays.

References
1. Advanced Healthcare Materials, 2202619, 2023
2. Nat. Comm, 13(1), 1-11, 2022
3. ACS Applied Materials & Interfaces, 12, 23 26893-26904, 2022

Short Biography:

Hyowon "Hugh" Lee is an associate professor at the Weldon School of Biomedical Engineering and the Director of Center for Implantable Devices at Purdue University. He received his M.S. and Ph.D. degrees in biomedical engineering from the University of California, Los Angeles, in 2008 and 2011, respectively, under the guidance of Jack Judy. Before joining Purdue, he worked as a senior process engineer for St. Jude Medical's Implantable Electronic Systems Division where he worked on manufacturing challenges associated with implantable electronic devices such as pacemakers, implantable cardioverter defibrillators, deep brain stimulators, and spinal cord stimulators. His current research interest centers around improving the reliability and functionality of implantable sensors and actuators. He is a recipient of the NSF CAREER award and he recently co-founded two medical devices startups. His lab is supported by NIH, NINDS, NIDA, NSF, Indiana CTSI, Samsung, and Eli Lilly.

Hydrogel-Based Biomaterials for Next-Generation Soft Electronics

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Abstract

In our research laboratory at Yonsei University, we focus on the development of soft electronics, with a particular emphasis on hydrogel-based biomaterials. This abstract outlines the main research themes and contributions of our lab. Firstly, we concentrate on the development of hydrogel-based electronic materials that closely resemble the properties of biological tissues, enabling their seamless integration within the human body. These materials are designed to be stretchable, self-healable, 3D-printable and adhering to the curved and moist environments found inside the body, thus facilitating optimal performance of hydrogel-based electronic components. Additionally, we investigate the development of lubricant-infused encapsulation materials that provide long-term protection to electronic devices from external factors such as bodily fluids, blood, proteins, and cells, which can otherwise lead to performance degradation. These encapsulation materials also act as protective barriers, maintaining the functionality and reliability of the electronic components over extended periods by reducing inflammatory responses of immune system. Another area of our research focuses on the development of conductive adhesives for bioelectronics. These adhesives are designed to be non-toxic and offer robust connectivity between the various components of bioelectronic devices, ensuring efficient and stable performance. Lastly, we explore the design and implementation of bioelectronic circuits with stretchable printed circuit board (PCB) layouts. This allows for the creation of flexible and stretchable electronic circuits that can conform to the dynamic movements and curvatures of the human body. The work conducted in our lab has significant implications for the advancement of soft electronics and their applications in various biomedical fields.

References

1. ACS Nano, on-line published (2023)
2. Advanced Science, 10, 22072 (2023)
3. Science Advances, 6 (44), eabb0025 (2020)

Short Biography:

Dr. Jungmok Seo is an associate professor in the School of Electrical and Electronic Engineering at Yonsei University. He received a Bachelor's and Ph.D. degree in Electrical and Electronic Engineering from Yonsei University. He served as a postdoctoral research fellow at Brigham and Women's Hospital and Harvard Medical School under the supervision of Professor Ali Khademhosseini. Dr. Seo's research focuses on the development of functional biomaterials and soft electronics for bio-integrative applications, specifically utilizing hydrogels and polymeric materials. His work aims to create innovative solutions that seamlessly integrate with biological systems, addressing critical needs in various biomedical fields.