IEEE CASS Workshop on Medical Wearables: Past, Present, Future

Co-located with BioCAS 2024, Xi'an, China

October 27, 2024, 8:00am – 12:15pm

Organizers:

Pamela Abshire, University of Maryland, College Park, USA

Abe Elfadel, Khalifa University, UAE

Final Program

Time	***Q&A (minutes)***	***Title***	***Speaker***
8:00 - 8:15		Welcome Note	Pamela Abshire (U. Maryland, USA) & Abe Elfadel (Khalifa U., UAE)
8:15 - 8:55	10	*Keynote: Wearable Healthcare: Past, Present and Future*	Jerald Yoo, SNU, Korea
9:05 - 9:25	5	*Next-Generation Wearable Blood Gas Monitors for Enhanced Patient Monitoring*	Ulkuhan Guler, WPI, USA
9:30 - 9:50	5	*Galvanic Body-Coupled Techniques for High-Speed Data and Power Transfer in Medical Applications*	Baibhab Chatterjee, UFL, USA
9:55 - 9:25		Tea Break & Photo	
10:25 - 10:45	5	*Intra-body power transfer for wearable devices*	Sohmyung Ha NYU Abu Dhabi, UAE
10:50 - 11:10	5	*Revolutionizing Healthcare: The Role of Wearable Sensors, Electronic Technology, and IEEE Standards*	Yongfu Li, Shanghai Jiao Tong University, China
11:15 - 12:15	Panel: Future Research and Commercialization Trajectories for Medical Wearables		A Panel of Experts (TBA)
12:15 - 13:00	Lunch		All





Title: Wearable Healthcare: Past, Present and Future

Abstract: Wearable healthcare targets mitigating the impact of chronic diseases by providing continuous yet adequate monitoring and analysis of physiological signals. However, the wearable environment is challenging for circuit and system designers due to unstable skin-electrode interface, huge mismatch, and static/dynamic offset. This talk will explore the past, present and future of wearable healthcare system with example systems. We will also cover the design strategies of wearable healthcare sensors, including the difficulties, limitations, and potential pitfalls in wearable interface circuit design, then the approaches to overcome such issues. Moving on, we will explorer the feature extraction and the patient-specific classification using on-chip Machine Learning technique. Finally, powering wearables through wireless body-area network (BAN) will be presented as well. We will conclude the talk with interesting aspects and opportunities that lie ahead.

Speaker: Jerald Yoo, Seoul National University, Korea (jerald@snu.ac.kr)

Jerald Yoo received the B.S., M.S., and Ph.D. degrees in EE, KAIST, Daejeon, Korea, in 2002, 2007, and 2010, respectively. From 2010 to 2016, he was with Masdar Institute, Abu Dhabi, United Arab Emirates, and between 2017 and 2024, he was with the ECE, National University of Singapore, Singapore, as an Associate Professor. Since 2024, he has been with the ECE, Seoul National University. He has pioneered research on Body-Area Network (BAN) transceivers for communication/powering, wearable bio-signal sensors, mobile ultrasound system and System-on-Chip (SoC) design to system realization for wearable healthcare applications. He is the recipient of IEEE International Solid-State Circuits Conference (ISSCC) 2020 and 2022 Demonstration Session Award, IEEE International Symposium on Circuits and Systems (ISCAS) 2015 Best Paper Award (BioCAS Track) and the IEEE Asian Solid-State Circuits Conference (A-SSCC) Outstanding Design Award (2005). He serves/has served as a Technical Program Committee Member of the IEEE ISSCC, CICC, A-SSCC and ISCAS. He is also a Steering Committee Member and was an Associate Editor of *IEEE Transactions on Biomedical Circuits and Systems (TBioCAS)* as well as an Associate Editor of *IEEE Open Journal of Solid-State Circuits Society (OJ-SSCS)*.

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Title: Next-Generation Wearable Blood Gas Monitors for Noninvasive Medical Applications

Abstract: The need for reliable monitoring of vital signs has become a key driver in advancing device technologies in modern digital healthcare. Oxygenation and ventilation, essential to assessing a patient's respiratory and metabolic health, hold significant importance beyond respiration alone. Noninvasive monitoring of blood oxygen and carbon dioxide levels, in particular, offers an alternative to the invasive gold standard methods traditionally used in clinical settings. While recent developments in wearable medical technology have enabled the monitoring of vital respiration parameters such as respiration rate and blood oxygen saturation, these represent only a subset of the critical measures required for comprehensive respiratory and metabolic health care. Blood oxygen and carbon dioxide partial pressures, key indicators of ventilation efficiency and metabolic function, are of great clinical significance and hold the potential to be monitored noninvasively. Noninvasive, wearable monitors for these parameters could revolutionize patient care, reducing dependence on invasive procedures and enabling more freedom for patients outside hospital settings. In this talk, the challenges and opportunities in designing wearable,

noninvasive systems to monitor oxygenation and ventilation will be explored. Key technologies driving advancements in this field will be highlighted, and the potential impact of these devices on personalized healthcare will be discussed.

Speaker: Ulkuhan Guler, Worcester Polytechnic Institute, MA, USA

Ulkuhan Guler is an associate professor of Electrical and Computer Engineering and director of the Integrated Circuits and Systems (ICAS) Laboratory at Worcester Polytechnic Institute (WPI), MA, USA. Before joining WPI in 2018, Dr. Guler was a postdoctoral researcher at Georgia Tech, GA, USA. She received her B.Sc. degree in Electronics and Telecommunication Engineering from the Istanbul Technical University, Istanbul, Turkey, her M.E degree in Electronics Engineering from the University of Tokyo, Tokyo, Japan, and her Ph.D. degree from Bogazici University, Istanbul, Turkey. Her research interests lie in the broad area of circuits and systems, and her primary area of interest is analog/mixed-signal integrated circuits. More specifically, she is interested in the circuit design of sensing interfaces, bioelectronics, energy harvesting and wireless power transmission systems, and security for applications in healthcare. Recently, her research interest has focused on determining how electronic interfaces can be engineered along with biosensors to facilitate the creation of wireless wearable sensors that measure physiological parameters in the human body. She is the recipient of the 2022 NSF CAREER award and the 2020 Interstellar Initiative Young Investigator award. She is a senior member of IEEE. She serves as an associate editor for several IEEE journals, including IEEE SSC-L, IEEE TBioCAS, and IEEE TCAS: II. Dr. Guler co-authored three book chapters. She also serves a steering committee member of the IEEE CICC and TPC member of the IEEE BioCAS conferences. In addition, she is a member of several solid-state circuits and circuits and system communities, including the Women in Circuits Committee. For more information: www.icaslab.org

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Title: Intra-body power transfer for wearable devices

Abstract: Intra-body power transfer (IBPT) is a technique that delivers power to distributed wearable devices though the human body. It has emerged as an alternative or even a complementary method to traditional energy harvesting (EH) and inductive wireless power transfer (WPT) as it can supply power to wearable devices regardless of their locations on the body. Moreover, IBPT enables the miniaturization of wearable sensor nodes by physically separating the bulky power source from the sensor load. It allows the power source to be placed at an optimal location on the body for EH or WPT. In this talk, basic principles, system modeling, challenges, and techniques of IBPT will be presented.

Speaker: Sohmyung Ha, New York University, Abu Dhabi, UAE

Professor Sohmyung Ha received the B.S (summa cum laude) and the M.S. degrees in Electrical Engineering from the Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, in 2004 and 2006, respectively. From 2006 to 2010, he worked at Samsung Electronics as a mixed-signal circuit designer for commercial multimedia devices. After this extended career in industry, he returned to academia as a Fulbright Scholar and obtained the M.S. and Ph.D. degrees in Bioengineering with the Engelson Best Ph.D. Thesis Award for Biomedical Engineering from the Department of

Bioengineering, University of California, San Diego, La Jolla, CA, USA, in 2015 and 2016, respectively. Since 2016, he has been with New York University Abu Dhabi, Abu Dhabi, UAE, which he is now Associate Professor of Electrical Engineering and Bioengineering. He currently serves as an associate editor of IEEE Transactions on Biomedical Circuits and Systems, IEEE Open Journal of the Solid-State Circuits Society, and Frontiers in Electronics and served as an associate editor of Smart Health (Elsevier) from 2016 to 2021. He is a member of the Analog Signal Processing Technical Committee (ASP TC) and the Biomedical and Life Science Circuits and Systems Technical Committee (BioCAS TC) of the IEEE Circuits and Systems Society (CASS). He is also a member of the IMMD Subcommittee of the International Technical Program Committee (ITPC) of the International Solid-State Circuits Conference (ISSCC).

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Title: Galvanic Body-Coupled Techniques for High-Speed Data and Power Transfer in Medical Applications

Abstract: Traditional wireless data and power transfer using electro-magnetic (EM) fields incur significant losses in case of biomedical implants due to absorption in the human body. As a result, alternative techniques such as Optical, Ultrasonic, Magneto-Electric and Body-Coupled signal transfer are being investigated heavily in the recent years. This talk will focus on the possibilities of high-speed (~10s of Mbps) wireless data transfer from the implants to a wearable using Galvanic Human Body Communication (HBC), which consumes only a fraction of the power required for traditional wireless. At the same time, to mitigate the challenges related to power transfer efficiency (PTE) from an external wearable to the implants, we shall present some of our recent works on Galvanic Body-Coupled Power transfer techniques that achieve better PTE and misalignment sensitivity than traditional wireless. This technology can have deep societal and scientific impact through energy-efficient and intelligent connected healthcare, brain-machine interfaces, and electroceuticals.

Speaker: Baibhab Chatterjee, University of Florida, USA (chatterjee.b@ufl.edu)

Baibhab Chatterjee is an Assistant Professor in the Department of Electrical and Computer Engineering (ECE) at the University of Florida, and directs the Wireless Intelligent Sensor Electronics (WISE) Lab. He received his Ph.D. from the Elmore Family School of Electrical Engineering, Purdue University, West Lafayette, IN, USA in 2022. Baibhab's industry experience includes two years as a Senior Digital Design Engineer with Intel, India, and one year as a Research and Development Engineer with Tejas Networks, India. He was with the IBM T.J. Watson Research Center, NY, USA during 2020-2021. Baibhab's works involve low-power analog, RF, and mixed-signal circuit design for energy-efficient and secure biomedical applications. He received multiple best paper/presentation awards in solid state circuits and security conferences including CICC 2019, CICC 2021, RFIC 3MT 2020, HOST 2018 and HOST 2019. His work on Galvanic and Bi-Phasic Communication in Brain Implants earned him the prestigious Eaton Award in Design Excellence in 2023. He serves as a Technical Program Committee Member in IEEE CICC, VLSID and CASES. https://chatterjee.ece.ufl.edu/

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Title: Revolutionizing Healthcare: The Role of Wearable Sensors, Electronic Technology, and IEEE Standards

Abstract: In this talk, *we* will explore the integration of advanced wearable sensors and electronic technologies in transforming healthcare into a smarter, more connected system. Beginning with an overview of the shift towards smart healthcare, we will trace the evolution of wearable sensors, highlighting their impact on remote monitoring and personalized care. The discussion will cover how IoT, telemedicine, and real-time data processing are reshaping healthcare delivery, with IEEE standards playing a crucial role in ensuring safety, interoperability, and efficiency. Looking forward, we will explore future trends like AI-powered diagnostics wearable sensors. Finally, a case study on the wearable digital stethoscope will demonstrate how these technologies can be applied in real-world healthcare settings. The talk will conclude with a call for cross-industry collaboration and the adoption of open-source data to drive the next wave of innovation in healthcare.

Speaker: Yongfu Li, Shanghai Jian Tong University, China

Yongfu Li (S'09-M'14-SM'18) received the B.Eng. and Ph.D. degrees from the Department of Electrical and Computing Engineering, National University of Singapore (NUS), Singapore, in 2009 and 2014, respectively. He was a research engineer with NUS, from 2013 to 2014. He was a senior engineer (2014-2016), principal engineer (2016-2018) and member of technical staff (2018-2019) with GLOBALFOUNDRIES, as a Design-to-Manufacturing (DFM) Computer-Aided Design (CAD) Research and Development engineer. He is currently an Associate Professor (tenured) with the Department of Micro and Nano Electronics Engineering and MoE Key Lab of Artificial Intelligence, Shanghai Jiao Tong University, China. His research interests include analog/mixed signal circuits, biomedical signal processing and circuit automation.