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## Welcome Letter

Dear Colleagues,

On behalf of the organizing committees, it is with great honor and enthusiasm that we extend a warm welcome to you for the flagship conference of the IEEE Engineering in Medicine and Biology Society (EMBS) in the field of wearable sensors and systems for digital health: the International Conference on Body Sensor Networks (IEEE BSN 2025). This year marks the 22nd anniversary of BSN, and we are proud to introduce a fresh theme for the conference, expanding its focus more broadly to sensing and AI for computational medicine.

BSN has consistently been at the forefront of pioneering research, encompassing cutting-edge advancements in devices and sensors, hardware and software systems, predictive models, and data analytics within the realm of healthcare and biomedicine. Following the resounding success of our 2024 meeting in Chicago, IL, we are excited to host BSN 2025 at the UCLA Meyer & Renee Luskin Conference Center in Los Angeles, CA, from November 3rd to 5th, 2025. For further information about the conference, please visit https://bsn.embs.org/2025/

BSN 2025 is proud to feature five oral sessions and two poster sessions that encompass a wide array of topics, including:

- Wearable and noninvasive sensing
- AI and sensing for clinical health
- Advanced sensing in neurophysiological care
- AI and modeling for diet and behavioral sciences
- Multimodal sensing and generative AI for personalized monitoring

In addition to these sessions, the conference has also extended invitations to four workshops and three tutorials, covering a diverse range of topics from wearable to AI for digital health:

- Sensor-informed, AI-driven closed loop systems for personalized medicine
- Medfusion: Multimodal data fusion for digital healthcare
- Addressing real-world stakeholders' needs for digital health technologies by adopting technology quality frameworks and individual properties
- Build personalized agentic chatbots: data, model, and knowledge in practice
- Tutorial: Beyond task-specific models: how foundation models can transform wearable sensor research
- Tutorial: Deep learning techniques for digital cardiac auscultation
- Tutorial: From lab to real-world impact: deploying multi-biosignal setups in-the-wild

For BSN 2025, a total of 158 regular four-page papers were submitted. These submissions underwent rigorous evaluation by the BSN 2025 technical program committee. Among these, 25 four-page papers, accounting for 15.8% of the submissions, were selected for oral presentations, while 75 papers, representing 47.5% of the submissions, were chosen for poster presentations. In addition to these paper submissions, we also received 90 one-page poster, demo, and clinical abstract submissions.

We have organized exciting joint events to enhance the BSN 2025 experience for all participants:

- Women in Engineering Society Luncheon, Tuesday, November 4
- Lunch to Speak with Faculty Mentors, Monday, November 3
- Conference Banquet at Top Gulf, Monday, November 3

Additionally, we are distinctly privileged to host three distinguished keynote speakers:

- Shrikanth (Shri) Narayanan, University of Southern California, USA
    - Biobehavioral Signal-based Machine Intelligence for Mental Health and Wellbeing
- Michelle Khine, University of California, Irvine, USA
    - From Children's Toy to Operating Room: Continuous Physiological Monitoring with Soft Electronics

- Eric Hekler, University of California, San Diego, USA
    - People are different. Context matters. Things change: Engineering the next generation of digital health interventions

To foster participant growth and excellence, we have curated three special sessions and two panel sessions featuring panelists from academia and the healthcare industry. Panelists will share their valuable insights, achievements in research innovation and commercial development, and their visionary perspectives on the future of healthcare.

- Clinical Panel: The Future of Remote Sensing for Sleep and Health
- Women in Engineering Panel
- Special Session: Beyond Task-Specific Models: How Foundation Models Can Transform Wearable Sensor Research, by Google
- Special Session: Toward Personalized Agentic Chatbot: Data, Model, and Knowledge, by UCI Institute for Future Health

In addition to these events, we have introduced initiatives to encourage knowledge sharing, innovation, and networking among conference attendees:

- All oral presentations, posters, and demos that align with the conference guidelines are eligible for award consideration, including Audience Choice awards.
- Exceptional papers will have the opportunity to be expanded and submitted as full papers to prominent journals in the fields of engineering in medicine and digital health, including the IEEE Open Journal of Engineering in Medicine and Biology.
- To facilitate fruitful scientific networking, we have arranged lunches, coffee breaks, a conference banquet, the Women in Engineering lunch, the graduate students symposium with faculty, and various social events. These gatherings provide a relaxed and informal context for participants to connect and collaborate.

The organizing committees of BSN 2025 extend their sincere appreciation to our valued sponsors, including Google, PLUX Biosignals, Labfront, UCLA, TAMU, ASU, and the National Science Foundation's (NSF) Smart and Connected Health program. Your generous support has been instrumental in making this conference a success. Additionally, the NSF and EMBS support has allowed us to distribute 37 student travel awards, helping to broaden participation in our field.

Furthermore, we express our gratitude to the IEEE Open Journal of Engineering in Medicine and Biology, PLOS Digital Health, Circulation: Cardiovascular Quality and Outcomes, Cardiovascular Digital Health Journal, and Frontiers in Digital Health for providing authors with the opportunity to expand and disseminate their research, which has further enriched the scholarly contributions of our conference.

We extend our heartfelt appreciation to the dedicated members of the steering committee, organizing committee, and technical program committee, as well as to our diligent reviewers, for their unwavering commitment and hard work in shaping an exceptional scientific program. We also express our gratitude to all authors who submitted their papers and to each of you for your presence, which contributes to the success of BSN 2025 and the sharing of your valuable work.

We are excited to have you join us for this momentous occasion, where we will share knowledge, engage in stimulating discussions, and forge new collaborations in the dynamic field of Body Sensor Networks. Your participation is integral to the success of IEEE BSN 2025, and we look forward to the wealth of insights and ideas that will emerge from this conference.

Sincerely,

Bobak Mortazavi, Majid Sarrafzadeh, and Sarah Sun
Conference Co-Chairs

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## Conference Venue

IEEE BSN 2025 will be held at the UCLA Meyer and Renee Luskin Conference Center.

The venue address is:

**UCLA Meyer and Renee Luskin Conference Center**

425 Westwood Plaza,
Los Angeles, CA 90095

**Program at a Glance**

<table>
<tr><th>Time</th><th>Nov. 03 2025 (MON)</th><th>Nov. 04 2025 (TUE)</th><th>Nov. 05 2025 (WED)</th></tr>
<tr><td>07:00 – 08:00</td><td rowspan="2">Conference registration & check in</td><td colspan="2">Conference registration & check in</td></tr>
<tr><td>08:00 – 08:30</td><td rowspan="3">Oral session #3</td><td rowspan="3">Oral session #5</td></tr>
<tr><td>08:30 – 09:00</td><td>Conference opening ceremony</td></tr>
<tr><td>09:00 – 09:30</td><td rowspan="3">Oral session #1</td></tr>
<tr><td>09:30 – 10:00</td><td rowspan="2">Special session: agentic AI for wearable sensors</td><td>Coffee break</td></tr>
<tr><td>10:00 – 10:30</td><td rowspan="2">Clinical Panel</td></tr>
<tr><td>10:30 – 11:00</td><td>Coffee break</td><td>Coffee break</td></tr>
<tr><td>11:00 – 12:00</td><td>Keynote 1: Shri Narayanan</td><td>Keynote 2: Michelle Khine</td><td>Highlighted talks: high school and PhD symposium</td></tr>
<tr><td>12:00 – 12:30</td><td rowspan="2">Lunch & PhD symposium with faculty</td><td rowspan="2">Lunch & WiE faculty meeting</td><td>Industry open table</td></tr>
<tr><td>12:30 – 13:00</td><td>Conference Close</td></tr>
<tr><td>13:00 – 14:00</td><td rowspan="3">Special session: Google foundation models for wearable sensors</td><td>Keynote 3: Eric Hekler</td><td rowspan="7">Workshops</td></tr>
<tr><td>14:00 – 14:15</td><td>Coffee break</td></tr>
<tr><td>14:15 – 14:30</td><td rowspan="2">Panel: Women in Engineering</td></tr>
<tr><td>14:30 – 15:00</td><td>Coffee break</td></tr>
<tr><td>15:00 – 16:00</td><td>Oral session #2</td><td>Oral session #4</td></tr>
<tr><td>16:00 – 17:00</td><td rowspan="2">Poster and demo session #1</td><td rowspan="2">Poster and demo session #2</td></tr>
<tr><td>17:00 – 18:00</td></tr>
<tr><td>18:30 – 20:00</td><td>Conference banquet at Top Golf (shuttle departs from Luskin at 18:10)</td><td colspan="2"></td></tr>
</table>

## Keynote Speakers

### Biobehavioral Signal-based Machine Intelligence for Mental Health and Wellbeing

**Date:** Monday, November 3, 2025

**Time:** 11:00 – 12:00

**Shrikanth (Shri) Narayanan**

University of Southern California, USA

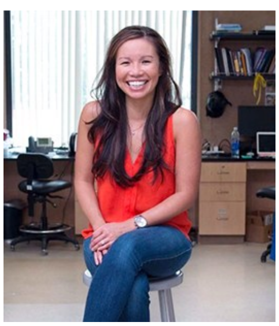
**Abstract:** Current approaches for assessing and tracking individual mental and behavioral well-being, and potential risk factors, through self-reports or behavioral interviews can be incomplete, unreliable, or simply unavailable to be of use in critical situations. Converging developments across the machine intelligence ecosystem, from human-centered multimodal sensing, signal processing and machine learning methods, are enabling new possibilities both in advancing science and in the creation of technologies supporting health research and its translation to practice.

Sensing, computing and AI-driven interface technologies are creating unprecedented opportunities for acquisition, analysis and sharing of diverse, information-rich data that allow causal and multimodal characterization of an individual's mental state with granularity, context, and scale not possible before. This includes behavioral machine intelligence—approaches for quantitatively and objectively understanding human behavior—with a specific focus on multimodal communicative, affective and social behavior. The talk will introduce aspects of multimodal signal driven machine intelligence and its applications using case study highlights spanning a range of domains from workplace health and wellbeing to those related to depression, suicide, and neurocognitive health across life span including Autism and Dementia.

### From Children's Toy to Operating Room: Continuous Physiological Monitoring with Soft Electronics

**Date:** Tuesday, November 4, 2025

**Time:** 11:00 – 12:00



**Michelle Khine**

University of California, Irvine, USA

**Abstract:** We know that physiological signals precede clinical deterioration. Yet our antiquated healthcare system is still rooted in episodic and reactionary-based care, in which patients are expected to travel to a centralized location for a healthcare provider to provide a snapshot-in-time assessment when they are overtly ill. Unless the symptoms are apparent at the time of examination, the subjective evaluation relies heavily on the patient's self-reporting of symptoms. This often results in delayed, inconclusive, or improper diagnoses. In response, we have developed a suite of soft, low-cost, unobtrusive, Band-Aid © like physiological sensors to continuously monitor patients' cardiovascular and pulmonary functions. We seek to continuously quantify subtle physiological changes to predict – and eventually prevent — the onset of acute clinical events.

**People are different. Context matters. Things change: Engineering the next generation of digital health interventions**

**Date:** Tuesday, November 4, 2025

**Time:** 13:00 – 14:00

**Eric Hekler**

University of California, San Diego, USA

**Abstract:** Digital health interventions for behavioral change face a fundamental challenge: traditional research methods assume population-level effects remain stable across individuals and time, while human behavior is inherently dynamic, context-dependent, and individually variable. This keynote traces a 15-year research journey that began with recognizing this methods-problem mismatch and culminated in successfully deploying adaptive, controller-based interventions in real-world settings. The story begins at Stanford, where we designed three mobile apps with different motivational frames to support older adults in becoming more physically active, compared against a diet tracking app as control. Using classical RCT methods, the social app "worked"—showing significant improvements versus control. However, examining the data more deeply, my mentor Abby King and I arrived at a troubling conclusion: different people needed different types of support at different times and contexts. Abby called this the "which's conundrum"—which intervention for which person at which time and in which place? This revealed a fundamental mismatch between behavioral complexity and methodological simplicity. A chance encounter with control systems engineer Daniel Rivera at a conference suggested a path forward. Though I didn't initially grasp the technical details, I recognized that control systems engineering might finally match the complexity of human behavioral dynamics. Joining Arizona State University where Daniel was faculty enabled systematic transdisciplinary collaboration spanning over a decade. Together, we co-led efforts to develop conceptual, methodological, and empirical foundations for a fundamentally new approach.

Key milestones, which will be discussed in the talk, included: (1) applying dynamical systems modeling to behavioral data, (2) computational modeling of Social Cognitive Theory as a dynamical system, (3) pilot studies demonstrating significant individual differences violating ergodicity assumptions, (4) developing the Control Optimization Trial (COT) framework integrating system identification with adaptive intervention delivery, and (5) philosophical arguments for complementing population-focused methods with individual-focused time-series approaches—embodied in the principle that "people are different, context matters, things change." This work enabled two major NIH/NSF-funded trials. The JustWalk JITAI study used nine-month system identification to identify personalized "just-in-time states" when individuals reliably increase walking when offered support. Results were striking: idiographic modeling identified reliable responsive states for 91% of participants, with effect sizes of 131-891 additional steps per three-hour period. Critically, population-level analysis of identical data detected no significant effects—vividly demonstrating how averaging masks individualized patterns. These patterns varied substantially: some responded best on weekday mornings with need and opportunity present, others on weekend afternoons when receptive. No single strategy worked for everyone, but nearly everyone had discoverable responsive patterns.

The YourMove study implemented our COT approach, deploying a model predictive controller that continuously adapted interventions based on individual responses from wearable sensors. We successfully demonstrated that sophisticated control algorithms can operate in real-world settings with consumer technology. While finalizing clinical trial results, the successful 12-month deployment of a scaled, adaptive controller represents proof-of-concept for a fundamentally different intervention paradigm. As wearable sensors become increasingly sophisticated and ubiquitous, infrastructure now exists to align intervention complexity with behavioral complexity. The question is no longer whether we can build adaptive, personalized systems at scale—we've shown we can. The question is: what will we build next leveraging next gen wearables?

**Clinical Panel: The Future of Remote Sensing for Sleep and Health**

**Date:** Wednesday, November 5, 2025

**Time:** 10:00 – 11:00

Jonathan Stange is an Associate Professor of Psychology and Psychiatry & the Behavioral Sciences at the University of Southern California, where he directs the Cognition and Affect Regulation Lab. Jon's research focuses on understanding mechanisms of affect regulation, as they relate to vulnerability for depression and suicide. His work integrates several levels of analysis, including fMRI, the autonomic nervous system, and behavior, both in the lab in people's everyday lives with ambulatory assessment. Jon's work has particularly focused on elucidating how people vary over time, and in what contexts might their risk for dysregulation may be greatest. The goal of his work is to identify personalized targets for intervention to help people to successfully self-regulate, and in doing so, to reduce risk for problems such as depression and suicide.

Dr. Monica Kelly is an Assistant Professor of Medicine at UCLA, a researcher at the VA Greater Los Angeles Geriatric Research, Education and Clinical Center (GRECC), and a licensed clinical psychologist, board-certified in Behavioral Sleep Medicine. Her research program centers on improving sleep as a critical contributor to physical and mental health, with a particular focus on older adults and individuals with posttraumatic stress disorder or spinal cord injury. Dr. Kelly's work frequently leverages sleep wearables such as actigraphy and home sleep apnea testing to advance remote measurement of sleep in both research and clinical practice. She is the lead author of a recently published book chapter, "Actigraphy and Behavioral Assessments of Sleep and Circadian Disorders," in the Oxford Handbook of Sleep and Sleep Disorders, underscoring her ongoing commitment to advancing remote sleep health monitoring in both research and clinical practice. Her research is currently funded by the National Heart, Lung, and Blood Institute (NHLBI) and the Craig H. Neilsen Foundation.

Professor Sara C. Mednick is a cognitive neuroscientist at the University of California, Irvine and author of The Power of the Downstate (Hachette Go!, pub date: April, 2022) and Take a Nap! Change Your Life. (Workman). She is passionate about understanding how the brain works through her research into sleep and the autonomic nervous system. Dr. Mednick's seven-bedroom sleep lab works literally around-the-clock to discover methods for boosting cognition by napping, stimulating the brain with electricity, sound and light, and pharmacology. Her lab also investigates how the menstrual cycle and aging affect the brain. Her science has been continuously federally funded (National Institute of Health, National Science Foundation, Department of Defense Office of Naval Research, DARPA).

## Special Session: Beyond Task-Specific Models: How Foundation Models Can Transform Wearable Sensor Research

**Date:** Monday, November 3, 2025

**Time:** 13:00 – 14:30

Unobtrusive, ubiquitous, and cost-effective wearable sensors have demonstrated the potential to revolutionize real-time monitoring of health and wellness by enabling the detection of various physical and mental health states. Machine learning models, in particular, play a crucial role in unlocking the full potential of this data, for example in the development of personalized and targeted therapy, enabling just-in-time interventions to aid in adherence and retention, or discovering of hidden behavior biomarkers to predict disease progression. However, training machine learning models on wearable sensor data remains challenging due to several key limitations: high susceptibility to noise and artifacts, frequent data missingness, the excessive computational resources required to train large neural networks, and the scarcity of large, high-quality public datasets.

The emergence of Foundation Models (FM) offers a new opportunity to address these challenges and accelerate our progress. In other domains such as natural language processing and computer vision, the foundation model paradigm has transformed the development of machine learning solutions to real-world problems. The key property of an FM is that it is pre-trained on a large-scale dataset to ensure that the resulting feature representation encompasses all of the complexity of the data domain, which is then validated by demonstrating that the FM can solve multiple downstream tasks without additional representation learning. In computer vision, the field has moved away from collecting individual special-purpose datasets and training task-specific models to leveraging existing foundation model representations, such as DINOv2 in solving a variety of perceptual tasks. A key enabling property is that, while the training datasets are private and not publicly available, the model weights are released to the research community, enabling everyone to benefit from its powerful representation. This transition in utilizing publicly available FMs has not yet occurred for mHealth, and it is a crucial next step.

There is a critical need to unite our community to foster strong collaborations to solve these challenges. While other domains have rapidly integrated breakthroughs in generative AI and large-scale foundation models, the health time-series domain has classically lagged behind, requiring careful reconciliation of these advances with domain-specific challenges. This tutorial aims to teach researchers working on wearable sensors how to utilize our LSM-2 foundation model in order to help with their research. LSM-2 is pre-trained on 40,000,000 hours of wearable sensor data from 60,440 persons with 128 Google v5e TPUs for 100k steps. LSM-2 achieves state-of-the-art performance on a range of downstream tasks from insulin resistance regression to activity recognition. Not only this, it is flexible enough to be used with varying sensor configurations, differing time windows, and specifically designed to be robust to missingness and noise.

**Special Session: Toward Personalized Agentic Chatbots: Data, Model, and Knowledge**

**Date:** Tuesday, November 4, 2025

**Time:** 9:30 – 10:30

Personalized Conversational Health Agents (CHAs) are emerging as a transformative technology in digital health, capable of providing tailored, context-aware insights and guidance through natural dialogue. They promise to move beyond static dashboards by turning raw data into actionable feedback that supports self-awareness, adherence, and preventive health.

In this tutorial, we will delve into the core components of Conversational Health Agents and examine how they enable personalized care. We will begin by discussing personal multimodal health data—including signals from wearables, mobile devices, and ecological momentary assessments—as the foundation for understanding individual health in context. We will show how digital and mobile health platforms are critical for integrating these diverse data streams, managing participant profiles, enabling real-time interventions, and ensuring scalability and privacy.

Next, we will discuss the role of knowledge bases, such as medical knowledge graphs and retrieval-augmented generation systems, and how they allow CHAs to apply domain knowledge in an accurate and explainable way. We will then explore multimodal analytic models, which make it possible to interpret diverse signals and combine subjective and objective data into meaningful insights. Together, we will demonstrate how these elements form the backbone of a new generation of adaptive, user-centered health support systems.

Finally, through examples and live demonstrations using the open-source CHA platform openCHA (opencha.com), we will show participants how to integrate multimodal data, digital health platforms, and conversational agents into study designs—providing a practical, reproducible framework for building and evaluating engaging, participant-centered digital health solutions. An optional, next-day Bootcamp will follow the tutorial, offering hands-on experience implementing these components end-to-end in openCHA.

**Monday, November 3, 2025**

**7:30 – 8:30**
**Conference registration & check in**

**8:30 – 9:00**
**Welcome Ceremony**
**Chair: Bobak Mortazavi**, TAMU, **Majid Sarrafzadeh**, UCLA, and **Sarah Sun**, UVA
**Room:** Ballroom A&B

**9:00 – 10:30**
**Technical Session #1: Wearable and Noninvasive Sensing**
**Chair: Rahim Esfandyar-Pour**, UC Irvine, and **Mobashir Shandhi**, ASU
**Room:** Ballroom A&B

Session 1: Wearable and Noninvasive Sensing

Monday, November 03, 2025, 09:00 – 10:30

**1. BrainDiffNet: Unified Semantic Encoders for Diffusion-based EEG-to-Image Generation**

*Shreyas Bellary Manjunath and Sreyasee Das Bhattacharjee, State University of New York at Buffalo, USA*

Gaining insight into the brain's visual representation through reconstructing what we see from brain activity is of immense importance and interest. Though fMRI and MEG achieve high-quality image reconstruction and classification, their cost and size restrict broader real-world applications, particularly outside clinical settings. In contrast, although Electroencephalography (EEG) is a cost-effective, non-invasive tool producing high temporal resolution signals, it remains less explored primarily due to its susceptibility to noise and complex spatio-temporal characteristics. To address these, we propose BrainDiffNet, an effective EEG-to-Image generation model that leverages a subject's contextual and EEG spatio-temporal information to guide a fine-tuned Stable Diffusion model, resulting in high-quality, semantically relevant images from brain activity. A robust Temporal Masked Autoencoder, designed for high-resolution EEG, enables the model to effectively extract features and manage noisy or incomplete EEG query representations. In-depth evaluation using the large-scale EEG-ImageNet dataset demonstrates the outperformance of BrainDiffNet in both tasks: Object Classification and Image Reconstruction. In fact, the model significantly outperforms state-of-the-art methods, achieving a 15 – 20% higher accuracy in classification across all granularity levels and a 7–12% improvement in all feature-specific two-way identification metrics for image reconstruction.

**2. Improved QRS Complex Detection in Capacitive ECG Measurements through Thick Clothing Using Capacitance Multiplier Circuit**

*Iori Kudo and Akinori Ueno, Tokyo Denki University, Japan*

In capacitive electrocardiography (cECG) measurements through thick clothing, signal attenuation in the coupling impedance owing to bulky clothes is a major challenge. This paper presents a capacitance multiplier circuit (CMC) to equivalently amplify the small capacitance of coupling to improve the detection performance of the QRS complex in cECG measurement. We acquired cECG signals using the proposed CMC from five male participants wearing 2.87 mm–thick clothing. The corresponding results reveal that the mean detection rates of sensitivity, accuracy, and positive predictive value exceed 95% by adjusting the amplification factor. Compared with a conventional measurement system without the CMC, the mean accuracy significantly increases by 57.0% ($p < 0.01$), and notable noise mitigation is achieved.

**3. A Crossbar GFET Platform with bioADC Integration for Multiplexed, Energy-Efficient Biosensing**

*Tyler Andrew Bodily, Min Suk Lee, Anirudh Ramanathan, Akshay Paul, Abhijith Karkisaval-Ganapati, Yuchen Xu, Oscar Vazquez-Mena, Ratnesh Lal, and Gert Cauwenberghs, University of California San Diego, USA*

We present platform technology consisting of a scalable, low-power graphene field- effect transistor (GFET) array integrated with a custom neural interface system-on-chip (NISoC) for multiplexed biosensing. The platform features a 10×10 GFET crossbar architecture with high-density channel integration and side-gated liquid sensing, enabling simultaneous detection of multiple bioana- lytes in a compact footprint. Electrical characterization under varying phosphate-buffered saline (PBS) concentrations confirms stable Dirac point behavior and sensitivity to ionic strength, highlighting the system's electrostatic responsiveness. Integration with a low-power bioADC-based NISoC supports both current- and voltage-clamp operation, achieving sub-μW/channel power consumption. Current-clamp mode offers enhanced energy efficiency, critical for continuous monitoring in wearable applications. A streamlined graphene transfer process and dielectric-isolated crossbar design ensure reproducible device performance across the array. The platform is being developed for surface functionalization with DNA aptamers to enable multiplexed biomarker detection in physiological fluids. These advancements position the system for real-time monitoring of health, stress, or disease markers in digital health and athletic performance settings. This work demonstrates a promising direction for next-generation wearable biosensors with low-power, high-density, and real-time signal acquisition capabilities.

### 4. A Thin Film Wireless Passive Multiplexed Wearable Biomarker Sensor

*Ruitong Chen and Ellis Meng, University of Southern California Los Angeles, USA*

Electrochemical sensor-integrated wearable devices can noninvasively monitor biomarkers present in sweat and interstitial fluid to provide insights on physiological health status. Current approaches often require rigid electrical components for signal processing and data transmission, which can negatively impact wearability. Passive sensing formats to eliminate rigid, discrete electronics have been explored but are largely limited to single marker detection. We investigate an alternative passive multiplexed sensing paradigm in which an entire system can be constructed in a thin, flexible film using polymer microfabrication techniques. Cortisol and sodium were selected as model molecules for the purpose of demonstrating wireless biomarker measurement using this system based on the principle of reflected impedance. Presence of each triggers changes in different circuit components of the secondary side equivalent, further demonstrating that sensing via different modes is possible using this a proof-of-concept multiplexed biomarker sensor constructed entirely on a flexible and biocompatible thin film.

### 5. PI-PPG: Motion-Robust and Bias-Reduced Wearable PPG via Light Polarization

*Shailabh Kumar, Jongboo Kim, InChun Lim, Sang Kyu Kim, Radwanul Hasan Siddique, Samsung*

Photoplethysmography (PPG) is widely used in wearable health monitoring, but conventional PPG sensors remain vulnerable to motion artifacts, ambient light interference, and skin-tone–related signal degradation. We present PI-PPG, a polarization-integrated PPG sensor system that improves signal fidelity and fairness in wearable cardiovascular monitoring. By combining high-efficiency polarized illumination with reflection-enhanced, cross-polarized detection, PI-PPG significantly reduces superficial scattering and motion-induced noise. Experimental validation across a range of Fitzpatrick skin types under both resting and active conditions demonstrates substantial gains, including >200% reduction in ambient light interference, >100% improvements in perfusion index and AC SNR, and >20% enhancement in cardiovascular feature detection. Notably, the system improves Heart Rate (HR) and Heart Rate Variability (HRV) accuracy by 28% for darker skin tones and reduces motion artifacts by 22% compared to conventional PPG. These advancements underscore the potential of PI-PPG to enhance detection efficiency, reliability, and fairness in wearable health sensing, thereby promoting equitable digital health solutions.

### 6. A Crossbar GFET Platform with bioADC Integration for Multiplexed, Energy-Efficient Biosensing

*Sheraz Hassan, Kefan Song, Alexander T Adams, Georgia Institute of Technology*

Laser speckle imaging is a powerful but underutilized optical technique, capable of capturing a range of physiological biomarkers, including heart rate, respiration, skin perfusion, hydration, and subtle structural changes in skin such as piloerection. Despite its proven efficacy in controlled settings, Laser speckle imaging is rarely found in wearable or point-of-care devices, which typically monitor only basic vital signs. To address this gap, we introduce \textbf{SkinSpex}: a compact, affordable device based on a Raspberry Pi Zero 2, integrating a multi-wavelength (560, 750, and 930 nm) laser system for flexible, non-contact speckle imaging. SkinSpex enables mapping of both hemodynamic and topographical skin features from a distance of just 10 cm, opening the door to multi-biomarker monitoring in everyday environments. Such comprehensive monitoring is especially relevant for detecting acute physiological states, including the sudden onset of opioid withdrawal, where changes in heart rate, breathing, and skin structure may occur simultaneously but are often missed by conventional wearables. By directly capturing both surface and subsurface skin dynamics, SkinSpex can provide a more complete view of physiological state, enabling earlier and more reliable detection of significant events. Our results show the unique capabilities of this compact prototype and suggest that SkinSpex could enable a new generation of wearable platforms for continuous, comprehensive health assessment across a variety of clinical and real-world settings.

**10:30 – 11:00**
**Coffee Break**

**11:00 – 12:00**
**Keynote Lecture: Biobehavioral Signal-based Machine Intelligence for Mental Health and Wellbeing**
**Speaker: Shri Narayanan,** University of Southern California
**Chair: Miguel Coimbra,** University of Porto, Portugal
**Room:** Ballroom A&B

**12:00 – 13:00**
**Lunch & PhD symposium with faculty**

**13:00 – 14:30**
**Special Session: Google Foundation Models for Wearable Sensors**
**Chair: Alexander T. Adams**, Georgia Tech
**Room:** Ballroom A&B

**14:30 – 15:00**
**Coffee Break**

**15:00 – 16:00**
**Technical Session #2: AI and Sensing for Clinical Health**
**Chair: Amanda Watson,** UVA, and **Diliang Chen**, UNH
**Room:** Ballroom A&B

Session 2: AI and Sensing for Clinical Health

Monday, November 03, 2025, 15:00 – 16:00

### 1. Atrial Fibrillation Prediction Using a Lightweight Temporal Convolutional and Selective State Space Architecture

*Yongbin Lee and Ki Chon, University of Connecticut*

Atrial fibrillation (AF) is the most common arrhythmia, increasing the risk of stroke, heart failure, and other cardiovascular complications. While AF detection algorithms perform well in identifying persistent AF, early-stage progression, such as paroxysmal AF (PAF), often goes undetected due to its sudden onset and short duration. However, undetected PAF can progress into sustained AF, increasing the risk of mortality and severe complications. Early prediction of AF offers an opportunity to reduce disease progression through preventive therapies, such as catecholamine-sparing agents or beta-blockers. In this study, we propose a lightweight deep learning model using only RR Intervals (RRIs), combining a Temporal Convolutional Network (TCN) for positional encoding with Mamba, a selective state space model, to enable early prediction of AF through efficient parallel sequence modeling. In subject-wise testing results, our model achieved a sensitivity of 0.908, specificity of 0.933, F1-score of 0.930, AUROC of 0.972, and AUPRC of 0.932. Additionally, our method demonstrates high computational efficiency, with only 73.5 thousand parameters and 38.3 MFLOPs, outperforming traditional Convolutional Neural Network–Recurrent Neural Network (CNN–RNN) approaches in both accuracy and model compactness. Notably, the model can predict AF up to two hours in advance using just 30 minutes of input data, providing enough lead time for preventive interventions.

### 2. Photoplethysmography Signals and their Correlation with Peripheral Artery Disease

*Ava Jean Fascetti, Mustafa H. Naguib, Elsie G. Ross, Chris Longhurst, Pam R. Taub, Shamim Nemati, Edward Wang, Mattheus Ramsis, University of California San Diego*

Peripheral Artery Disease (PAD) is a common atherosclerotic condition that is underdiagnosed due to the lack of accessible screening options. Photoplethysmography (PPG) serves as a potentially valuable tool in accessible screening for PAD due to its ubiquitous nature and ability to be measured on a smartphone. However, the relationship between PPG and PAD is underexplored. In this paper, we seek to identify features of a PPG signal that correlate with PAD. In an analysis of 5,237 legs from N=2,362 unique patients, we find significant correlations with multiple different features and the ankle-brachial index (ABI), which is used to diagnose PAD. Additionally, these features agree with physiological explanations of PAD and how the disease affects blood flow. These results set up the ability of future work to develop an accessible screening tool for PAD that uses physiologically relevant features of PPG morphology.

### 3. Enabling Intelligent Resuscitation: Non-Invasive Cardiac Output Monitoring via Physiological Sensing and Machine Learning

*Demet Tangolar, Onur Selim Kilic, Samuel Liu, Cem Okan Yaldiz, Jacob P. Kimball, Omer T. Inan, Georgia Institute of Technology*

Accurate, continuous monitoring of cardiac output (CO) is crucial for effective resuscitation management in hemorrhagic trauma, yet current gold-standard methods are invasive and impractical in field settings. This study introduces a fully non-invasive and wearable sensing-based approach utilizing electrocardiography (ECG), seismocardiography (SCG), and photoplethysmography (PPG) signals, integrated with machine learning algorithms, to enable stroke volume (SV) and CO estimation without requiring baseline calibration or normalization. This critical feature makes the model especially suitable for casualty care scenarios where baseline measurements are often unavailable. The proposed methodology was evaluated on a porcine model (n=6) subjected to controlled hemorrhage and resuscitation protocols. Clinically-validated cardiovascular features were used as inputs for regression models, including linear, ridge, LASSO, random forest, and XGBoost regressors. Among these, the LASSO demonstrated the best performance, achieving a high correlation (R=0.79) and a mean absolute percentage error (MAPE) of 14.31, well within clinically-acceptable limits for non-invasive CO monitoring. The framework reliably tracked SV trends crucial for clinical decision-making during resuscitation scenarios. This work highlights the potential for intelligent, non-invasive CO monitoring systems to improve clinical and trauma care outcomes.

### 4. Heart Rate Monitoring Through ANC Headphones in Unconstrained Environments

*Zhenyu Wu, Maanya Shanker, Tao Chen, Xiaoran Fan, Longfei Shangguan, University of Pittsburgh*

This paper introduces CLEAR-APG, a novel acoustic sensing approach that enables reliable heart rate monitoring in unconstrained environments using off-the-shelf active noise cancellation (ANC) headphones. By emitting ultrasonic signals into the user's ear canal via the headphone speaker and analyzing their echoes, which can detect the frequency of a pulsating vein along the canal wall. However, everyday activities such as exercising, speaking, or eating cause jaw movements that deform the ear canal, overwhelming the subtle deformation caused by blood flowing. To overcome this challenge, we employ the ANC headphone’s built-in gyroscope to capture body motion and identify how various motion patterns influence the heartbeat waveform. Building on this insight, we propose a multi-modal method that effectively denoises the heartbeat waveform measurements and further accurately extracts heart rate. We implement CLEAR-APG on ANC earbuds and conduct comprehensive field studies on 14 users. The results show that CLEAR-APG achieves an average heart rate error of 4.01% across seven different activities, satisfying industry-required margin of 10% heart rate error.

**16:00 – 18:00**
**Poster and Demo Session #1**

Poster and Demo Session #1

Monday, November 03, 2025, 16:00 – 18:00

**Technical Posters, Demos, and Abstracts**

[10] Intra-Body Backscattering for Wearable Ring Sensor
[16] Estimating Knee Joint Contact Forces During Daily Activities Using a Five-IMU Setup
[22] Non-Contact Health Monitoring During Daily Personal Care Routines
[30] Mitigating Thermal Expansion Effects in Silicone-Coated Pelvic Floor Muscle Dynamometer
[34] Sensor-Augmented Proning Vest for Continuous Acoustic and Impedance-Based Respiratory Assessment
[44] Short-Term Physiological Forecasting with Adaptive Covariance Matrix Estimation
[48] Generalizable Blood Pressure Estimation from Multi-Wavelength PPG Using Curriculum-Adversarial Learning
[50] Rapid Adaptation of SpO2 Estimation to Wearable Devices via Transfer Learning on Low-Sampling-Rate PPG
[52] Enhanced Accuracy in Respiratory Movement Detection Using Simultaneously Measured Body Proximity Signals via a Capacitive Sheet Electrode
[55] Smart Cane with ToF-Based Obstacle Detection and Multimodal Feedback for Visually Impaired Users
[56] A Self-Powered, Flexible Triboelectric Nanogenerator for Wireless Sensor Systems
[60] BabyBelt: A Low-Cost Wearable Uterine Contraction Monitoring Belt Using Velostat Sensors
[69] Into the Wild: Reliable Physiological Sensing with on-device Autoencoder-based Anomaly Detection
[75] Fingertip Impedance Plethysmography: A New Window Into Peripheral Blood Flow
[82] Evaluating and Enhancing Radar-Based Fall Detection with Diffusion-Generated Synthetic Data
[84] AFairDNet: Actively Empowering Fair Multisensor Emotion Recognition with Chain-of-Thought on Diffused Biosignals
[87] Where is the Boundary? Multimodal Sensor Fusion Test Bench for Tissue Boundary Delineation
[91] Smartphone-Based Real-Time Respiration Tracking with Dual-Sided Inkjet-Printed Wearable Electrodes
[100] mV-IMU: mmWave-enabled Virtual Inertia Measurement Unit for High-fidelity Activities of Daily Living Monitoring
[102] Comparative Analysis of Diffusion Models for Enhancing Alzheimer’s Disease Classification
[104] ReBoot: A SMART SHOE SYSTEM FOR IN-HOME PARKINSON S MOTOR ASSESSMENTS
[106] Design and Feasibility of a Game-Oriented Balance Board for Rehabilitation Adherence Potential
[108] Wearable PPG-to-Multi-Lead ECG Conversion for Cardiac Monitoring
[109] Language-agnostic Speech Biomarker Exploration for Early Dementia Screening
[112] Tuning In to Nerve Activity: Audio-Inspired Features for Sympathetic State Detection
[114] Feasibility Analysis of Integrating Wearable Cortisol Sensor Data with Machine Learning for Physical Fatigue Identification in Construction Workers
[117] Symbol-Temporal Consistency Self-Supervised Learning for Robust Time Series Classification
[125] Motivating Adherence to Symptom Reporting Among Patients with Cancer: Pilot Study
[126] Smart Glasses for Monitoring Eye Damage Risk from UV Exposure
[129] Impact of JIA-Related Physiology on Machine Learning-Based Task Prediction Performance from Active Acoustics-Driven Achilles Tendon Sensing: A Proof-of-Concept Study
[133] Time-Aware Cross-Attention for Multi-Modal Sensor-Based Blood Glucose Forecasting
[136] Non-invasive Glucose Measurement using Radio-Frequency Spectroscopy and Machine Learning
[138] Design of a CMOS FD-NIRS System With Fully Integrated Analog Front-End and Readout
[141] A Multi-Task LLM Framework for Multimodal Speech-Based Mental Health Prediction
[147] MedCoT-RAG: Causal Chain-of-Thought RAG for Medical Question Answering
[163] Time-Dependent FEM Modeling for Transcutaneous Oxygen Sensors
[166] Improving Responsiveness in Game-based Cognitive Assessment for Mild Cognitive Impairment
[A6] Poster: Predicting Six-Month Ambulation After Incomplete Spinal Cord Injury With Daytime Limb-Acceleration
[A8] Poster: ELSA: Monitoring EMG and Shoulder Joint Kinematics for Post-operative Shoulder Recovery

[A9] Poster: Exploring the Correlation Between Freezing of Gait and Postural Changes in Parkinson s Disease
[D13] Demo: Intra-Body Backscattering for Wearable Ring Sensor
[A17] Heartbeat-based Non-contact Biometrics using a Conditional Variational Autoencoder
[A18] Deep Learning-Based Reconstruction of 12-Lead ECG Using a 16-Channel Flexible Sensor
[D19] Demo: Precision-Timed Optogenetic Stimulation for Obstructive Sleep Apnea Using Intraoral Sensor Fusion and Late Fusion Deep Learning
[A22] POSTER: Modeling Glucose Dynamics Across Varying Sampling Frequencies in Data-Sparse Environments
[A25] Quantifying Physiological Parameters of HCT Patients and Their Caregivers From Wearables For Post-Transplant Effects Monitoring
[A26] Poster: A Wireless Power-Optimized Smart Pillow System for Contactless In-Home Health Monitoring
[A30] Hybrid video and wearable monitoring reveals blunted heart rate response to sit-to-stand transitions in Parkinson s disease in a simulated apartment
[D33] MINDER: Wearable Biofeedback for Opioid Use Disorder
[D35] Demo: Conversational Health Agents for Personalized Insights from Multimodal Data
[A37] Toward Electromechanical Measurement of Muscle Activity
[A38] Poster: Feasibility of Hand-to-Hand Bioimpedance for Assessing Cardiovascular Parameters
[A41] Poster: Quantifying Small Peak Detectability from Wearable Electrocardiography During Movement
[A43] Poster: Cluster-Driven Modeling to Enable Personalized Gesture Classification
[A46] Wearable Bioimpedance Sleeve with Integrated IMUs for Adaptive Knee Osteoarthritis Rehabilitation
[A47] Poster: Optimization of Low-Cost Flex Sensor Performance Using Machine Learning
[A49] Using Gaze to Train a Closed-loop Adaptive Neuromotor Interface for Diverse Tasks
[A51] Poster: From Stress to Distress: A Personalized Detection Approach Using Gaussian Process Regression
[A52] Passive Detection of Eating Episodes using Continuous Glucose Monitors
[A54] Poster: Flexible Ultrathin Temperature Sensor Array as a Patch for Early Breast Cancer Detection
[A55] Wearable-Sensor Assessment of Music Listening as a Preventive Strategy for Stress Inoculation
[D60] Demo: Adaptive Digital Health Interventions for Childhood Mental Health From Wearable Screening to Personalized Recommenders
[A62] A Privacy-Preserving On-Device Architecture for Generating SOAP Notes from Patient Health Data
[A64] Compact DMA Sensor for Soft Tissue Characterization
[A66] Antelligence: LLM-Powered Swarm Simulation with Biomedical Extensions
[A69] Breaking the Cycle of Stress: Exercise as a Regulator of Academic Pressure
[A73] Predicting periodontal severity via machine learning
[A74] GlucoGuide: A Retrospective Counterfactual Decision Support to Address Stakeholder Needs
[D75] Demo – Optimizing Inference on On-device Language Models for Stress Prediction
[A76] Non-invasive Multi-Modal Biosignal Wearable for Companion Animals
[A78] Poster: A Comparative Analysis of Generative Adversarial Networks (GAN) Architectures for Data Augmentation of Physiological Signals
[A79] A Comparative Feasibility Study of ECG, PPG, and Acoustic Sensors for Canine Heart Rate Variability (HRV) Measurement
[A81] Poster: Pilot Study for a Pediatric Stroke Exergaming System
[A82] Highly Stretchable and Conductive Inks for Printed Circuits
[A83] A Closed-Loop System for Real-Time Hypertension Management via Non-Invasive Median Nerve Stimulation

**18:00 – 20:00**
**Conference Banquet**
**Venue: Top Golf**

Shuttle will be provided from and to Luskin. Shuttle departs from Luskin to Top Golf at 18:10.

**Tuesday, November 4, 2025**

**7:30 – 8:00**
**Conference registration & check in**

**8:00 – 9:30**
**Technical Session #3: Advanced Sensing in Neurophysiological Care**
**Chair: Sarah Sun**, UVA and **Chenhan Xu,** NCSU
**Room:** Ballroom A&B

Session 3: Advanced Sensing in Neurophysiological Care

Tuesday, November 04, 2025, 08:00 – 09:30

### 1. Respiratory Attractor Dynamics and Their Association with Symptom Burden in COPD

*Passara Chanchotisatien, DK Arvind, University of Edinburgh, UK*

Chronic obstructive pulmonary disease (COPD) is characterised by persistent respiratory symptoms and activity limitations. While tools like the COPD Assessment Test (CAT) enable self-reported monitoring, they lack physiological objectivity and temporal resolution. This study investigates the use of \textit{phase-space attractor reconstruction}, a nonlinear time-series method, for symptom tracking using respiratory signals from a chest-worn accelerometer. Data from 12 COPD patients over four to six weeks were segmented using a CNN-BiGRU-based activity classifier to isolate stationary periods. \textit{Attractor reconstructions} were computed at 60-second intervals, and 112 features spanning geometric, spectral, and topological domains were extracted. Several features showed noteworthy correlations with total and item-level CAT scores, supporting their potential as objective markers of symptom burden. These results highlight the feasibility of attractor-based analysis for non-invasive, continuous COPD monitoring and personalised disease management.

### 2. Sub-centimeter Probes for Low-Frequency Alternating Electric Field (AEF) Measurements in Rodent Models of Brain Cancer

*Marinus H. Daling, David Durfee, Turner Shelton, Samuel Simonian, Keith Schubert, Sabbir Khan, Chirag B. Patel, Vincent W. Leung, Baylor University*

The FDA has approved therapeutic low frequency alternating electric fields (AEFs), called tumor treating fields (TTFields), for the treatment of patients with glioblastoma, malignant pleural mesothelioma, and non-small cell lung cancer. Accurate measurements of these fields in rodent models are critical for the pre-clinical development and testing of combinatorial therapeutic strategies involving AEF before they can be translated to human clinical trials. This paper presents a novel 3mm diameter electric field probe capable of measuring such fields. The probe demonstrates a measurable field range of 0.1-10 Vpp/cm at 200 kHz. The proposed probe significantly outperforms a commercially available stub probe with a measurement error of 18 % in a known field, compared to an error of 94.4 % for the commercial probe. Measurement of an applied AEF in a rat skull, with electrodes similar to those used in clinical trials, is also demonstrated with a maximum measurement error of ±5.5 % between three different probes. This simple sensor is made from commercially available components and operates over a wide range of frequencies and field strengths, making it ideal for preclinical AEF validation and potentially transferable to future clinical applications.

### 3. Smart Ankleband for Plug-and-Play Hand-Prosthetic Control

*Dean Zadok, Oren Salzman, Alon Wolf, Alex M. Bronstein, Technion - IIT*

Building robotic prostheses requires a sensor-based interface designed to provide the robotic hand with the control required to perform hand gestures. Traditional Electromyography (EMG) based prosthetics and emerging alternatives often face limitations such as muscle-activation limitations, high cost, and complex calibrations. In this paper, we present a low-cost robotic system composed of a smart ankleband for intuitive, calibration-free control of a robotic hand, and a robotic prosthetic hand that executes actions corresponding to leg gestures. The ankleband integrates an Inertial Measurement Unit (IMU) sensor with a lightweight neural

network to infer user-intended leg gestures from motion data. Our system represents a significant step towards higher adoption rates of robotic prostheses among arm amputees, as it enables one to operate a prosthetic hand using a low-cost, low-power, and calibration-free solution. To evaluate our work, we collected data from 10 subjects and tested our prototype ankleband with a robotic hand on an individual with an upper-limb amputation. Our results demonstrate that this system empowers users to perform daily tasks more efficiently, requiring few compensatory movements.

### 4. Situational Signal Processing with Ecological Momentary Assessment: Advancing Speech Vocoder Implementation for Naturalistic Cochlear Implant Scenarios

*Taylor Lawson, John H. L. Hansen, University of Texas at Dallas*

Cochlear implants (CIs) are surgically implanted medical devices that rely on real-time digital signal processing (DSP) strategies for acoustic-to-sound conversion. Because most fixed strategies have been implemented and tested only in clinical and laboratory settings, the ability for CI systems to adapt to varied feedback in spontaneous environments is limited. To help allocate real-time CI feedback in naturalistic spaces, this study proposes the first CI framework for situational signal processing: "Emaging", and considers CI vocoded testing approaches to help record and document collected data when CI users are often difficult to recruit for experimental testing. This unprecedented application implements ecological momentary assessment (EMA), an "on-the-go" data collection method for instantaneous feedback from CI subjects. The "Emaging" algorithm solution runs on portable devices alongside CCi-MOBILE, a customized portable CI signal processing platform. This study evaluates two parameters of EMA for the CI participant: sound source localization (SSL) and sound source identification (SSI) for non-spoken sounds. With "Emaging", CI users document and "tag" situational data from their naturalistic environments in real-time. Due to the many constraints with CI subject recruitment and testing, vocoded simulations with normal hearing (NH) participants can contribute valuable information and considerations aptly integrated with CI algorithm development. "Emaging" and its collected responses from CI, NH, and vocoded (V) subjects provides a unique opportunity for next generational CI processing design that integrates effective sound coding strategies for non-linguistic sound intelligibility and source localization.

### 5. Enabling High Temporal-Resolution Remote Monitoring in Resource-Constrained Implantable Medical Devices with Human Body Communication

*Ayan Biswas, Baibhab Chatterjee, Shreyas Sen, Purdue University*

Continuous remote monitoring of implantable medical devices, such as pacemakers, is limited by the high power consumption and security concerns of traditional wireless technologies like Bluetooth. In this work, we investigate Electro-Quasistatic Human Body Communication (EQS-HBC) as an alternative, leveraging the body itself as a communication channel between implants and werable devices. EQS-HBC achieves real-time, high-throughput data transmission at power levels approximately 100 times lower than Bluetooth, enabling millisecond-resolution monitoring with minimal impact on device longevity. Through system-level optimization of sensing, memory, and communication, we demonstrate that EQS-HBC can support high temporal-resolution, secure data exchange without the high battery life penalties of current Radio-Frequency (RF) based solutions. These results highlight EQS-HBC's potential to transform remote care for patients by making truly continuous, personalized monitoring feasible.

### 6. In-Vivo Training for Deep Brain Stimulation

*Nicholas Carter, Arkaprava Gupta, Prateek Ganguli, Vibhor Krishna, Benedikt Dietrich, Samarjit Chakraborty, UNC Chapel Hill*

Deep Brain Stimulation (DBS) is a highly effective treatment for Parkinson's Disease (PD). Recent research uses reinforcement learning (RL) for DBS, with RL agents modulating the stimulation frequency and amplitude. But, these models rely on biomarkers that are not measurable in patients and are only present in brain-on-chip (BoC) simulations. In this work, we present an RL-based DBS approach that adapts these stimulation parameters according to brain activity measurable in vivo. Using a TD3 based RL agent trained on a model of the basal ganglia region of the brain, we see a greater suppression of biomarkers correlated with PD severity, compared to modern clinical DBS implementations. Our agent outperforms the standard clinical approaches in suppressing PD biomarkers while relying on information that can be measured in a real world environment, thereby opening up the possibility of training personalized RL agents specific to individual patient needs.

**9:30 – 10:30**
**Special Session: Agentic AI for Wearable Sensors**
**Room:** Ballroom A&B

**10:30 – 11:00**
**Coffee Break**

**11:00 – 12:00**
**Keynote Lecture:** From Children's Toy to Operating Room: Continuous Physiological Monitoring with Soft Electronics
**Speaker: Michelle Khine,** University of California, Irvine
**Chair: Jessilyn Dunn**, Duke University
**Room:** Ballroom A&B

**12:00 – 13:00**
**Lunch & WiE Meeting**

**13:00 – 14:00**
**Keynote Lecture: People are different. Context matters. Things change: Engineering the next generation of digital health interventions**
**Speaker: Erik Hekler,** University of California, San Diego
**Chair: Amir Rahmani**, UC Irvine
**Room:** Ballroom A&B

**14:00 – 14:15**
**Coffee Break**

**14:15 – 15:00**
**Women in Engineering Panel**
**Chair: Jessilyn Dunn**, Duke University, and **Bryn Loftness**, University of Vermont
**Room:** Ballroom A&B

**15:00 – 16:00**
**Technical Session #4: AI and Modeling for Diet and Behavioral Sciences**
**Chair: Hassan Ghasemzadeh**, ASU, and **Corey Baker**, USC
**Room:** Ballroom A&B

Session 4: AI and Modeling for Diet and Behavioral Sciences

Tuesday, November 04, 2025, 15:00 – 16:00

### 1. AZT1D: A Real-World Dataset for Type 1 Diabetes

*Saman Khamesian, Asiful Arefeen, Bithika M. Thompson, Maria Adela Grando, Hassan Ghasemzadeh, Arizona State University*

High-quality real-world datasets are essential for advancing data-driven approaches in type 1 diabetes (T1D) management, including personalized therapy design, digital twin systems, and glucose prediction models. However, progress in this area has been limited by the scarcity of publicly available datasets that offer detailed and comprehensive patient data. To address this gap, we present AZT1D, a dataset containing data collected from 25 individuals with T1D on automated insulin delivery (AID) systems. AZT1D includes continuous glucose monitoring (CGM) data, insulin pump and insulin administration data, carbohydrate intake, and device mode (regular, sleep, and exercise) obtained over 6–8 weeks for each patient. Notably, the dataset provides granular details on bolus insulin delivery (i.e., total dose, bolus type, correction-specific amounts) features that are rarely found in existing datasets. By offering rich, naturalistic data, AZT1D supports a wide range of artificial intelligence and machine learning applications aimed at improving clinical decision-making and individualized care in T1D.

### 2. A Multimodal AI-Enabled Framework for Characterizing Overeating Behaviors and Consumption Patterns

*Farzad Shahabi, Jessica Li, Chris Romano, Rowan McCloskey, Glenn J. Fernandes, Mahdi Pedram, Jacob Schauer, Tammy Stump, Nabil Alshurafa, Northwestern University*

Overeating is a key contributor to obesity, yet identifying and characterizing its underlying causes remains challenging. While prior research has leveraged Ecological Momentary Assessment (EMA) to capture psychological and contextual factors in real-time, few studies have integrated EMA with passive sensing to uncover fine-grained, individualized consumption behaviors. In this work, we present a multimodal framework combining psychological and contextual data from a custom-built EMA app with validated camera-derived meal microstructure features from a neck-worn activity-oriented wearable camera. Across 41 participants, the camera captured 6,343 hours of footage over 312 days, yielding annotated bites, chews, meal start/end times, and dietitian-confirmed caloric intake. Using supervised contrastive learning, we generated meal-level representations, projected them using UMAP, and applied k-means clustering to identify behavioral phenotypes. We then conducted a z-score analysis to highlight features most distinctive to each cluster. Among the eight discovered groups, three consistently showed high purity for overeating meals (average purity = 0.99), revealing nuanced, data-driven overeating phenotypes that may inform targeted intervention strategies.

### 3. Health-driven Personalized Metabolic Models of Postprandial Glucose Responses to Mixed Meals

*Anurag Das, Ghady Nasrallah, Sicong Huang, Bobak J Mortazavi, Ricardo Gutierrez-Osuna, Texas A&M University*

The relationship between the macronutrient composition of a meal and the resulting post-prandial glucose response is complex given the large inter-individual differences in metabolism. We present JointCGMacros, a computational model that learns a joint embedding of meal macronutrients and postprandial glucose, mediated by demographics, metabolic health, and gut microbiota variables. The model extracts parallel embeddings from (1) postprandial glucose responses to a meal, and (2) the meal's macronutrient composition conditioned on health parameters using a triplet loss. The macronutrient embedding is an interpretable parametric expression that captures how health parameters modulate the effect of individual macronutrients. We evaluated the model on an experimental dataset containing postprandial glucose responses to a variety of mixed meals from subjects with different metabolic health status (healthy, pre-diabetes, type 2 diabetes). JointCGMacros significantly outperforms a model that attempts to predict macronutrients directly from postprandial glucose. These findings may lead to the development of automatic dietary monitoring using off-the-shelf wearable devices.

### 4. SigmaScheduling: Uncertainty-Informed Scheduling of Decision Points for Intelligent Mobile Health Interventions

*Asim H. Gazi, Bhanu Teja Gullapalli, Daiqi Gao, Benjamin M. Marlin, Vivek Shetty, Susan Murphy, Harvard University*

Timely decision making is critical to the effectiveness of mobile health (mHealth) interventions. At predefined timepoints called "decision points," intelligent mHealth systems such as just-in-time adaptive interventions (JITAIs) estimate an individual's biobehavioral context from sensor or survey data and determine whether and how to intervene. For interventions targeting habitual behavior (e.g., oral hygiene), effectiveness often hinges on delivering support shortly before the target behavior is likely to occur. Current practice schedules decision points at a fixed interval (e.g., one hour) before user-provided behavior times, and the fixed interval is kept the same for all individuals. However, this one-size-fits-all approach performs poorly for individuals with irregular routines, often scheduling decision points after the target behavior has already occurred, rendering interventions ineffective. In this paper, we propose SigmaScheduling, a method to dynamically schedule decision points based on uncertainty in predicted behavior times. When behavior timing is more predictable, SigmaScheduling schedules decision points closer to the predicted behavior time; when timing is less certain, SigmaScheduling schedules decision points earlier, increasing the likelihood of timely intervention. We evaluated SigmaScheduling using real-world data from 68 participants in a 10-week trial of Oralytics, a JITAI designed to improve daily toothbrushing. SigmaScheduling increased the likelihood that decision points preceded brushing events in at least 70% of cases, preserving opportunities to intervene and impact behavior. Our results indicate that SigmaScheduling can advance precision mHealth, particularly for JITAIs targeting time-sensitive, habitual behaviors such as oral hygiene or dietary habits.

**16:00 – 18:00**
**Poster and Demo Session #2**
**Room:** Ballroom C&D

Poster and Demo Session #2

Tuesday, November 04, 2025, 16:00 – 18:00

### Technical Posters, Demos, and Abstracts

[4] COACT: Collaborative Objective AI-Assisted Clinical Team Assessment in Emergency Medicine
[5] Analysis of Driver Behavior in Various Events Using Electrodermal Activity Signal
[28] Comparing Quantization Methods for On-Edge ECG Interpretation using Multi-Task CNN
[33] Reading the Digital Pulse: Context-Aware AI for Sensing Engagement Drivers in Health Forums
[38] MindCare: An Innovative Application for Depression Diagnosis and Treatment Support
[42] PSAFE: Extraction of Faint Fetal PPG from Non-Invasively Acquired Mixed PPG Signals
[45] Self-Supervised and Topological Signal-Quality Assessment for Any PPG Device
[49] The Impact of Protected Variable Integration in Multimodal Pretraining: A Case Study on ECG Waveforms and ECG Notes Pretraining
[51] SenseCF: LLM-Prompted Counterfactuals for Intervention and Sensor Data Augmentation
[66] Graph-Based Analysis of Electroretinograms for Reducing Computational Complexity and Classifying Neurodevelopmental Disorders
[70] MR-Tidal: A System for Efficient Respiration Tracking in Clinically Constrictive Environments
[72] ToF Based Wearable Sensing for Passive Food Intake Monitoring
[76] Batteryless Gesture Recognition Via Learned Sampling
[81] Wireless Low-Latency Synchronization for Body-Worn Multi-Node Systems in Sports
[83] PPGWeaver: Diffusion-Augmented Models for Real-Time Heart Rate Estimation on Microcontrollers
[86] Multimodal Deep Learning for Phyllodes Tumor Classification from Ultrasound and Clinical Data
[92] CAN-STRESS: A Real-World Multimodal Dataset for Understanding Cannabis Use, Stress, and Physiological Responses
[98] Ear-ECG Denoising Using Heart Sounds and the Extended Kalman Filter
[101] Quantifying Opioid Withdrawal through Cardio-mechanical Variability using Multi-modal Wearable Sensors
[105] FoodAgent: A Multi-modal Mixture of Experts Reasoning Agent for Divide-and-Conquer Food Nutrition Estimation
[107] Hand-Grip Strength Estimation through Bioacoustic Sensing
[110] VitalWave: An End-to-End Open-Source High-Frequency Wearable Device and Data Collection Platform
[111] φ-Fetus: A Phantom In-utero Fetus for Fetal Heart Simulation
[127] Robust PCA-Based Dimensionality Reduction in Human Hand Coordination
[130] Simulation-Based Evaluation of AC vs DC Electrodermal Activity Measurement Circuits for Long-Term Wearable Applications
[135] Initial Assessment of Dye Incorporation in Bombyx mori Silk Biomaterials
[139] Meda: Mobile DC-EDA Circuit Validation
[140] Predicting Craving-Related Emotions among Opioid Use Disorder Patients: Preliminary Results
[142] EdgeEMG: On-Device Neural Network Training for Real-Time EMG Pattern Recognition
[143] WatchAnxiety: A Transfer Learning Approach for State Anxiety Prediction from Smartwatch Data

[146] AGILE: A Multi-task Contrastive Learning Framework with Adversarial Gradient Iterative Learning for Bio-signal Anonymization
[151] Transcutaneous Median Nerve Stimulation Regulates Peripheral Skin Temperature During Cold Pressor: A Sham-Controlled Study
[152] RayWatch: Hemispherical Diffusion on Wrist UV Sensor for Indoor-Outdoor Sensing
[153] Robustness of Persistence Diagrams to Time-Delay for Seismocardiogram Signal Quality Assessment
[154] Hybrid ST-GCN/HMM Tremor Detector for a Wearable MR-Fluid Exoskeleton
[156] Ubiquitous Embroidered Electrodes: An Open-Source Platform for Biopotential Measurement
[158] Physiological and Cognitive Responses to Walking in Natural and Built Urban Environments
[A4] Label-Free Electrical Profiling of Senescent Cells via Frequency-Modulated Dielectrophoresis
[D5] Demo: HiveGuard: Intelligent EEG Wearable Helmet with Honeycomb Structure
[D7] Oscillometric Smartphone Blood Pressure Demo
[A10] Monitoring the Effects of Medication in Parkinson s Disease Using Wearable Sensors in an Unsupervised Home Setting
[A12] Preliminary Validation of Analog Devices VSM Watch Heart Rate Estimation
[A15] Automatic Detection of Alzheimer s Disease Using Wearable Single-Lead ECG Sensor
[A16] Fetal ECG Extraction Using a Variational Autoencoder and a Flexible Abdominal Sensor
[A20] Machine Learning Prediction of All-Cause 30-Day Hospital Readmission in COPD Patients
[A21] AI-Driven Electrochemical Biosensor for the Early Diagnosis of Lung Cancer Associated Risks
[A23] Poster: Head-worn Vibrotactile Biofeedback System Used to Address Bilateral Vestibular Impairment
[A24] Poster: Non-Invasive Thoracic Bioimpedance System for Continuous CHF Fluid Monitoring
[A27] Poster: FrailCam: Monocular Camera Frailty Assessment
[A28] Poster Increasing Precision In Finger Force Transmission Analysis: The Role Of The Angulodiginychium
[A29] Poster: Discreet Wearable Human Computer Interfaces Based on Hydrographic Paper
[A31] Analyzing multi-camera video data for posture change detection to assess orthostatic dysautonomia in Parkinson s disease
[A34] Comparing Literature Algorithms to Derive Physical Activity Endpoints from a Wrist Accelerometer
[A36] Poster: Multimodal Physiological and EEG Analysis for Firefighter Stress and Fatigue Monitoring
[A40] Design of a Real-Time Rehabilitation System for Runners with Patellofemoral Pain Syndrome
[A48] Cardiac Output Monitoring via an Automatic Arm Cuff Device: Potential in Surgical Patients
[A53] A Lightweight Machine Learning Model for Stress Detection Using a Custom Wearable with ECG and Respiration Signal Fusion
[A57] TDA-Aware Long Short-Term Memory Model Improves Accuracy of Human Activity Recognition
[A58] TurtleTrack: Continuously Improving Sitting Posture using a Wearable Device
[A61] Poster: Wearable Auscultation System for Early Detection of Congenital Pediatric Heart Disease
[A67] Poster: Quantitative Multispectral Imaging for Bruise Aging Across All Skin Tones
[A71] Wearable-Based Detection of Caffeine-Induced Physiological Changes and Concentration in High School Students
[A72] Virtual Neurostimulation for Seizure Control A Computational Study of Epileptic Network Dynamics
[A77] Poster: Evaluating Functional Training Performance with Pose Estimation
[A80] Poster: Unsupervised Video Human Fatigue Detection via Landmark Time Series Chain

## Clinical Abstracts

[C1] Predicting Fracture Healing with Wearable Gait Sensors and Machine Learning: A Comparative Analysis of Model and Feature Selection Strategies
[C2] Smartwatch-Derived Digital Biomarkers for Detecting Early Signs of Cognitive Decline in Older Adults
[C3] Personal Emergency Response Systems with Social Support Improve Health in Older Adults and Reduce Hospital Costs
[C4] Speech Biomarkers from a Motor Cognitive Dual-Task Detects Early Cognitive Decline in Older Adults

[C5] Interactive, Self-Administered Home-Based Exercise Program for Individuals with Mild Cognitive Impairment and Mild Dementia: Initial Results from a Randomized Controlled Trial

[C6] Smart Prompts for Smart Healing: Boosting Adherence in Patients with Diabetic Foot Ulcer: Initial Results from a Randomized Controlled Trial

[C7] Multichannel Stethoscope Array for Pediatric Pulmonary Patients and Temporospatial Analysis

[C8] A Decision Tree Model for Identifying Patients at Risk of Suboptimal CPAP Support

[C12] Integrating clinical and technical expertise: Uniting clinical and technical domains to validate and strengthen findings

[C13] Sequence-Aware Models of Eye Movements during Passage Reading Enables More Precise Assessment of Ataxia

[C14] Altered Wearable-Monitored Heart Rate Variability During Sleep in Adolescent Girls with Depression

[C15] Enhancing Clinical Outcomes in AVM Embolization: A Novel Computational Flow Model for Treatment Planning

**Wednesday, November 5, 2025**

| **7:30 – 8:00**<br>**Conference registration & check in** |
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| **8:00 – 9:30**<br>**Technical session #5: Multimodal Sensing and Generative AI for Personalized Monitoring**<br>**Chair: Miguel Coimbra**, University of Porto, Portugal, and **Mobashir Shandhi**, ASU<br>**Room:** Ballroom A&B |
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Session 5: Multimodal Sensing and Generative AI for Personalized Monitoring

Wednesday, November 05, 2025, 08:00 – 09:30

### 1. Capturing Resting Cardiovascular Coupling as an Indicator of Orthostatic Hypotension using a Multimodal Chest-Worn Patch

*Vikram Abbaraju, John A. Berkebile, Paul A. Beach, Omer T. Inan, Georgia Institute of Technology*

Orthostatic hypotension (OH), caused by efferent baroreflex failure, can lead to syncope and is associated with high mortality rates among individuals with neurodegenerative diseases. Several studies in recent years have aimed to estimate baroreflex sensitivity (BRS) during orthostatic stressors using measures of cardiovascular coupling (CVC): the degree of synchronization between time series cardiovascular signals. However, these efforts have relied on blood pressure sensing using bulky, wired setups, and the majority have only quantified changes in CVC during or after the occurrence of OH. In this study, we characterized CVC at rest in $N = 26$ participants (20 with a neurodegenerative disease) using a chest-worn patch that recorded electrocardiogram (ECG) and photoplethysmogram (PPG) signals. From the ECG and PPG data recorded during a 5-minute supine rest period prior to an orthostatic challenge, we derived interbeat interval (IBI) and PPG amplitude (PPGamp) time series features as indices of cardiac rhythm and vascular function, respectively. We then quantified the coupling between IBI and PPGamp using time delay stability (TDS). Following an active standing test, 12 participants experienced OH. We found that mean TDS during the rest period was 22.9% lower in the OH group than in the no-OH group ($p < 0.01$). Furthermore, we found that resting TDS was moderately correlated with the change in systolic blood pressure from supine to standing ($\rho = 0.43$, $p < 0.05$). Thus, we demonstrated the effectiveness of a multimodal wearable in capturing a marker of impaired resting CVC prior to OH occurrence. This work enables the deployment of wearable sensing for estimating BRS to assist with early screening of autonomic dysfunction in the future.

### 2. TouchWave: Exploring mmWave-based Non-contact Fingertip-force Sensing in Activities of Daily Living

*Yuliang Fu, Zhi Zhang, Rakshita Ranganath, Zhizhen Li, Yuchen Liu, Ning Sui, Huining Li, Chenhan Xu, NC State University*

Fingertip forces are important biomarkers for the detection and management of various conditions, including stroke and Parkinson’s disease. This paper presents TouchWave, a non-contact sensing system designed to monitor fingertip forces during activities of daily living (ADL). TouchWave leverages under-cabinet millimeter-wave (mmWave) sensors to capture both macroscopic hand movements and subtle biomechanical cues associated with fingertip force production. A novel signal processing scheme is developed to suppress noise while preserving force-related information in the mmWave signals. Additionally, a hybrid deep neural network model is proposed to estimate high-fidelity fingertip forces. A comprehensive evaluation involving 21 participants demonstrates the effectiveness of TouchWave in both controlled settings and ADL scenarios.

### 3. Domain-Specific Constitutional AI: Enhancing Safety in Mental Health LLMs

*Chenhan Lyu, Yutong Song, Pengfei Zhang, Amir M. Rahmani, UCI*

Mental health applications have emerged as a critical area in computational health, driven by rising global rates of mental illness, the integration of AI in psychological care, and the need for scalable solutions in underserved communities. These include therapy chatbots, crisis detection, and wellness platforms handling sensitive data, requiring specialized AI safety beyond general safeguards due to emotional vulnerability, risks like misdiagnosis or symptom exacerbation, and precise management of vulnerable states to avoid severe outcomes such as self-harm or loss of trust. Despite AI safety advances, general safeguards inadequately address mental health-specific challenges, including crisis intervention accuracy to avert escalations, therapeutic guideline adherence to prevent misinformation, scale limitations in resource-constrained settings, and adaptation to nuanced dialogues where generics may introduce biases or miss distress signals. We introduce an approach to apply Constitutional AI training with domain-specific mental health principles for safe, domain-adapted CAI systems in computational mental health applications.

### 4. Transformer-Based Full-Body Pose Estimation for Rehabilitation via RGB Camera and IMU Fusion

*Yuanshuo Tan, Xinyuan He, Guoxing Liu, Licheng Zhong, Huiming Pan, Kezhe Zhu, Peter Shull, Shanghai Jiaotong University*

Rehabilitation training plays a vital role in the recovery of lower back and cervical spine function. Human pose estimation can support this process by guiding and evaluating rehabilitation movements. However, specialized rehabilitation exercises often involve severe self-occlusions, posing significant challenges for vision-based pose estimation methods. We thus propose a full-body pose estimation framework tailored for rehabilitation exercises, which fuses monocular images and inertial measurement unit (IMU) signals using a temporal transformer. Multimodal data was collected from six subjects performing 22 specialized rehabilitation movements (e.g., single-leg open book, cross-leg body rotation, standing iliotibial band stretch, standing lumbar extension). The collected data comprises synchronized images, 2D and 3D human keypoint coordinates, and IMU signals. Our approach first employs a convolutional neural network (CNN) to extract 2D keypoints from image sequences. These keypoints, combined with IMU signals, are then processed by a temporal transformer to estimate 3D joint coordinates. On the collected data, a vision-only baseline yields a 2D joint position error of 7.33±2.08 pixels and a 3D joint error of 10.05±2.67 cm. In comparison, the proposed approach achieves lower errors, with 5.50±0.75 pixels for 2D joints and 8.27±1.03 cm for 3D joints. By leveraging inertial data, our approach enhances the robustness of pose estimation under challenging conditions such as self-occlusion, demonstrating its potential for both clinical and home-based rehabilitation applications.

### 5. Text2IMU: Advancing Human Activity Recognition by Text-Driven IMU Data Synthesis

*Lars Ole Haeusler, Lena Uhlenberg, Oliver Amft, University of Freiburg*

Inspired by the progress of motion synthesis models, we leverage cross-modality transfer to generate realistic synthetic Inertial Measurement Unit (IMU) data from textual descriptions, hence Text2IMU. We use an established motion synthesis model and textual descriptions to generate sequences of 3D human activities. To obtain realistic and diverse sensor readings, we created multiple body surface models with different body morphologies. With the text prompts, we let the surface models perform activities and synthesise acceleration and gyroscope data for multiple virtual IMU positions. We show that synthetic data, generated by Text2IMU, can be used to classify activities across three public benchmark datasets. We demonstrate that our Text2IMU synthesis approach does not require measured data of the target domain. Text2IMU yields an average Human Activity Recognition (HAR) accuracy of 79.2% for correctly synthesised activities, which doubles the performance of synthetic sensor data obtained from baseline models. We demonstrate that synthetic HAR model training can replace empirical data acquisition when the prompted activities can be successfully generated.

**9:30 – 10:00**
**Coffee Break**

**10:00 – 11:00**
**Clinical panel: The Future of Remote Sensing for Sleep and Health**
**Chairs: Brandon Oubre**, UAB, and **Katharine Simon**, UC Irvine
**Room:** Ballroom A&B

**11:00-12:00**
**Special Session: Highlighted Award Talks**
**Chairs: Bobak Mortazavi**, TAMU, and **Brandon Oubre**, UAB
**Room:** Ballroom A&B

**12:00-12:30**
**Industry Open Table**

**12:30-13:00**
**Conference Closing Ceremony**
**Chair: Bobak Mortazavi**, TAMU
**Room:** Ballroom A&B

**13:00-17:00**
**Workshops**

Workshop 1
Sensor-informed, AI-driven closed loop systems for personalized medicine
Location: 289 – Engineering VI

Workshop 2
Medfusion: Multimodal data fusion for digital healthcare
Location: Maxwell 57-124 Engineering IV

Workshop 3
Addressing real-world stakeholders' needs for digital health technologies by adopting technology quality frameworks and individual properties
Location: 364 Engineering IV

Workshop 4
Build personalized agentic chatbots: data, model, and knowledge in practice
Location: 6764 Boelter

Tutorial 1
Beyond task-specific models: how foundation models can transform wearable sensor research
Location: Luskin main conference room

Tutorial 2
Deep learning techniques for digital cardiac auscultation
Location: 4275 Boelter

Tutorial 3
From lab to real-world impact: deploying multi-biosignal setups in-the-wild
Location: 37-124 Engineering IV