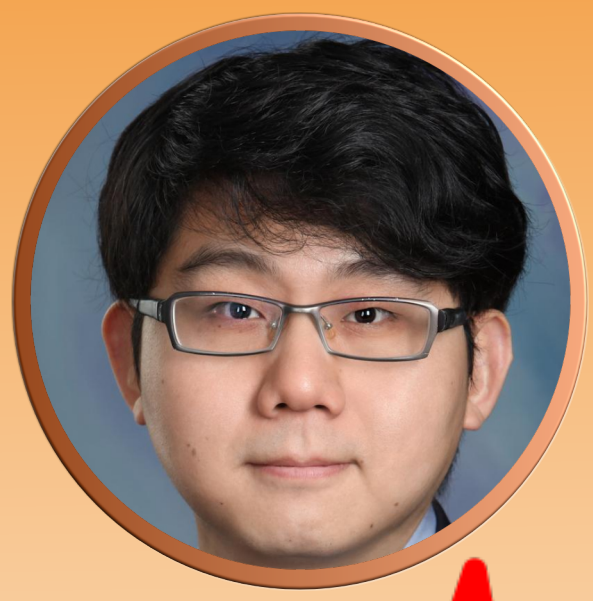
NUS National University of Singapore | iHealthtech Institute for Health Innovation & Technology

"Innovating Health" Seminar
Outstanding Young Speaker Series

24 JUN, TUE, 11:15 AM –12:15 PM

NUS, College of Design and Engineering, Building E7, Level 3, Seminar Room 4



Dr Liu Jia

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Soft and Flexible Bioelectronics for Brain-Machine Interfaces and NeuroAI

Hosted by Dr Wu Changsheng, iHealthtech Principal Investigator

Understanding brain function through large-scale brain-machine interfaces (BMIs) is essential for deciphering neural dynamics, treating neurological disorders, and developing advanced neuroprosthetics. A grand challenge in this field is to achieve simultaneous, large-scale, stable recording of neural activity, with single-cell resolution, millisecond precision, and cell-type specificity across three-dimensional (3D) brain tissue, throughout development, learning, and aging. In this talk, I will introduce a suite of soft and flexible bioelectronic technologies engineered to meet this challenge and enable the development of NeuroAI systems inspired by biological intelligence.

First, I will present tissue-like bioelectronics, capable of tracking the activity of individual neurons in behaving animals across their entire adult life. I will address the electrochemical limitations of soft materials and share our strategies to overcome them, establishing a scalable platform for large-scale, stable, and long-term brain mapping, compatible for human clinical applications.

Next, I will discuss the creation of "cyborg organisms" by integrating stretchable mesh-like electrode arrays into 2D sheets of stem/progenitor cells, which undergo 2D-to-3D morphogenesis to form brain organoids or embryonic brains. This enables continuous 3D electrophysiological recording during development. I will then highlight how the brain's dynamic nature—and the challenge of capturing neural changes over time—can be addressed using our stable electronics to decode neural representational drift. These platforms support long-term, adaptive neural decoding and facilitate integration with neuromorphic algorithms for real-time interpretation of intrinsic neural dynamics.

Building on this, I will introduce DriftNet, a deep neural network framework inspired by neural dynamics. DriftNet mitigates catastrophic forgetting, outperforming conventional and state-of-the-art lifelong learning models and equipping large language models with cost-effective, NeuroAI-driven lifelong learning capabilities.

Finally, I will present our latest efforts integrating 3D single-cell spatial transcriptomics, electrophysiology, and agentic AI to map brain activity with cell-type specificity. I will conclude by outlining a future vision where soft electronics, spatial omics, and AI agents converge to construct a comprehensive brain cell functional atlas, transforming next-generation BMI and NeuroAI applications.

Speaker biography:

Professor Liu received his PhD in Chemistry from Harvard University in 2014, after which he completed postdoctoral research at Stanford University from 2015-2018. He joined the faculty at the Harvard School of Engineering and Applied Sciences as an Assistant Professor in 2019. At Harvard University, Professor Liu's lab focuses on the development of soft bioelectronics, cyborg engineering, genetic/genomic engineering, and computational tools for addressing questions in brain-machine interfaces, neuroscience, cardiac diseases, and developmental disorders. Professor Liu has pioneered in bioelectronics where he developed new paradigms for soft electronic materials and nanoelectronics architectures for "tissue-like electronics", as well as their applications for long-term stable brain-machine interface, high-density cardiac mapping, stem cell maturation, and multimodal spatial biology. His work has been recognized as a milestone in bioelectronics by Science in 2013 and 2017, and as Most Notable Chemistry Research and Top 10 World-Changing Ideas in 2015. He has received numerous awards for his independent career, including the 2022 Inventors Under 35 (Global List) by MIT Technology Review, the 2022 Young Investigator Program (YIP) Award from the Air Force Office of Scientific Research (AFOSR), the 2021 NIH/NIDDK Catalyst Award from the NIH Director's Pioneer Award Program, the 2020 William F. Milton Award, and the 2019 Aramont Award for Emerging Science Research Fellowship. He is also the cofounder and scientific advisor of Axoft, Inc., a brain-machine interface company.

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