IEEE ICMA 2025 Conference

Invited Talk Session on Soft Mechatronics Systems

Monday, August 4, 2025
11:00 - 12:30
Jinyuan Banquet Hall
Beijing Empark Grand Hotel, Beijing, China

Venue: Jinyuan Banquet Hall
Beijing Empark Grand Hotel, Beijing

Date and Time: 11:00 - 12:30, August 4, 2025

Organizers:

Prof. Chengzhi Hu, Southern University of Science and Technology, China
Prof. Yajing Shen, Hong Kong Univ. of Science and Tech., Hong Kong SAR, China

About the invited Session:

This invited session will focus on the basic research and potential application of soft mechatronics systems. We invited five speakers to deliver talks, discuss the new research topics and challenge.

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Invited Talk 1

Development of Bioinspired Dynamic Soft Robots

Aiguo Ming, Ph.D.

Professor

The University of Electro-Communications, Tokyo, Japan

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Abstract:

The evolution process for creatures is very, very long and contains many useful secrets and rationality mostly hidden in their structure, motion and configuration. Authors' group has been working on how to introduce creatures' structure and propulsion mechanism into soft robots to realize high mobility, efficient and creature like motions. The main challenge topic is how to design and control the soft robots with considering the synergetic coupling between soft structure and environment (air, water, etc.). In this talk, our basic approach toward the synergy will be introduced, and as the case studies some examples of the developed soft robots (fast caudal fin propulsion underwater robot, holonomic underwater robot using two-dimensional propulsion, very soft underwater robot, flapping robot with asymmetric and nonlinear structure, etc.) will be shown.

Short Bio

Aiguo Ming (Member, IEEE) received the Ph.D. degree in precision machinery engineering from The University of Tokyo, Tokyo, Japan, in 1990. He is currently a Professor with the Department of Mechanical Engineering and Intelligent Systems, The University of Electro-Communications (UEC), Chofu, Tokyo, Japan. His current research interests include biomimetic hyperdynamic robotics, soft robotics, intelligent robotic hands, and precise measurement systems.

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Invited Talk 2

Magnetic Field Based Soft Tactile Sensor for Robot

Yajing Shen (申亚京) , Ph.D.

Associate Professor

the Department of Electronic and Computer Engineering

Director of Center for Smart Manufacturing

Hong Kong University of Science and Technology

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Abstract:

The rapid advancement of robotics has significantly transformed various industries; however, achieving accurate tactile perception remains a formidable challenge. This talk discusses the development of a magnetic field-based soft tactile sensor, highlighting its potential applications in robotics. We will explore the underlying principles of the sensor's design, its operational mechanisms, and the experimental results that demonstrate its effectiveness in various scenarios. Furthermore, the talk will examine the implications of this technology for improving robotic interactions and functionality, paving the way for more sophisticated and responsive robotic systems.

Short Bio:

Prof. Yajing Shen is currently an Associate Professor in the Department of Electronic & Computer Engineering at The Hong Kong University of Science and Technology, Hong Kong, China. His mainly research interest is miniature intelligent robotic system, particularly in bioinspired miniature robotics and human-robot interaction. He has published more than 200 peer reviewed journal/conference papers, including the top multidisciplinary journal (e.g., Science Robotics, Science Advances, Nature Communications, PNAS), top specialized journal (e.g., IEEE Trans on Robotics), with widely fetched by international media, e.g., Associated Press, Thomson Reuters, etc. He received the Best Manipulation Paper Award in IEEE International Conference on Robotics and Automation (ICRA) in 2011, the IEEE Robotics and Automation Society Japan Chapter Young Award in 2011, the Early Career Awards of Hong Kong UGC in 2014, the Big-on-Small Award at MARSS in 2018, IEEE Distinguish lecture in 2019, CityU Outstanding Supervisor Award in 2020. He also received the “National Excellent Young Scientist Fund (Hong Kong & Macau)” for the topic “micro/nano robot” in 2019.

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Invited Talk 3

Wireless Reliability Challenges in Gastrointestinal Ingestible Electronics

Hen-Wei Huang, Ph.D.

Assistant Professor

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Abstract:

Ingestible electronics offer a promising platform for rapid screening of gastrointestinal (GI) conditions, but robust wireless communication remains a core challenge. This talk highlights key electromagnetic constraints imposed by the GI environment, including high tissue attenuation, dynamic dielectric properties, and power limitations.
We evaluate signal propagation across sub-GHz to 6 GHz bands, showing that fluid-rich tissues and variable fat/muscle layers induce significant frequency-dependent loss. Local factors—such as pH (1–8), gastric volume, and intestinal content—shift antenna resonant frequency and degrade link reliability. Frequent reorientation of the capsule due to GI motility leads to severe misalignment losses, underscoring the importance of omnidirectional or orientation-resilient antenna design. High transmission power to overcome these effects is energy-inefficient for battery-constrained systems. We demonstrate that a PID controller can effectively reduce the power consumption while maintaining the RSSI and data through at a desired level.
By addressing frequency detuning, orientation variability, and tissue loading jointly, this talk outlines a path toward reliable, energy-efficient wireless links for next-generation ingestible diagnostics.

Short Bio

Dr. Hen-Wei Huang received his BS and MS in mechanical engineering from National Taiwan University, in 2011 and 2012, respectively. In 2018, he received his Ph.D. in robotics from ETH Zurich under the supervision of Prof. Bradley J. Nelson. His doctoral research focused on engineering soft reconfigurable micromachines that can emulate the locomotion and shape adaption to the local environments of their natural counterparts like Trypanosoma brucei and Caenorhabditis elegans. Before pursuing his Ph.D., he was an R&D engineer in a startup company developing a pocket-size cuffless blood pressure monitor from 2013 to 2014. He joined the MIT Langer Lab to conduct his postdoctoral research in 2018 where he was focusing on introducing robotics into controlled drug delivery to enable automated closed-loop therapies. He is also co-founder of AIO Therapeutics since 2021, focusing on using robotics to enhance patients' adherence to their medication. Before joining NTU Singapore, he was an Assistant Professor of the Department of Medicine at Harvard Medical School and an Associate Scientist at Brigham and Women’s Hospital since 2021. Currently, he is a Nanyang Assistant Professor at NTU, Singapore. He is also affiliated with the LKC Medicine. His current research interests involve robotics and AI for emergency medicine, therapeutic decision-making, and non-invasive diagnosis and treatment.

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Invited Talk 4

Smart swarms at microscale: how tiny robots learn to work collectively

Hongri (Richard) Gu, Ph.D.

Assistant Professor

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Abstract:

Nature abounds with small bodies achieving outsized feats—ants lift prey many times their mass and kinesin motors haul vesicles through the cytoskeleton. Translating these cooperative principles to the micrometer scale, however, demands new control paradigms that can cope with Brownian noise, tight physical coupling, and severe hardware constraints. Here I present a laser-controlled swarm of up to 200 Janus microrobots (6 μm diameter) whose individual actions are optimized by multi-agent reinforcement learning (MARL). A counterfactual reward scheme quantifies each robot's marginal contribution by virtually "removing" it from the team at every timestep; this credit-assignment strategy eliminates the "lazy agent" problem, accelerates training, and yields robust collective policies despite thermal disturbances and unpredictable cargo–robot interactions. The learned policy enables the swarm to gather, align, and transport rod-shaped loads an order of magnitude heavier than a single robot while adaptively reconfiguring when units are lost. By fusing bio-inspired mechanics with learning-based autonomy, we take the next step toward microrobotic collectives that think, cooperate, and ultimately transport drugs inside the human body.

Short Bio

Hongri (Richard) Gu is currently an assistant professor at division of Integrated System and Design (ISD), Hong Kong University of Science and Technology (HKUST).

He studied mechatronic engineering at Zhejiang University from 2009 to 2014. During his Bachelor's program, he joined Young Scientist Exchange Program at the Tokyo Institute of Technology from 2012 to 2014. Later he started the Master's program in Micro and Nano System at ETH Zurich and finished in 2016. From 2017 to 2021, he performed doctoral research at Multi-Scale Robotics Lab, ETH Zurich under Prof. Brad Nelson. From 2022 to 2024, He did his postdoc at Department of Physics, University of Konstanz, Germany.

His research focuses on developing structured magnetic materials and robotic systems for future disruptive medical technologies, through investigating the multi-scale physiological transport and inventing new medical devices and surgical tools.

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Invited Talk 5

Efficient Active Perception and Mobile Manipulation with Autonomous Robots

Boyu Zhou, Ph.D.

Assistant Professor

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Abstract:

In recent years, unmanned aerial vehicles (UAVs) have garnered significant attention due to their high flexibility and mobility. This talk will present research on UAVs in the areas of active perception and mobile manipulation, with applications in inspection and logistics. First, we will introduce methods for autonomous drones to efficiently explore unknown environments, including advancements in real-time planning, efficient environmental representation, and swarm collaboration. Next, we will discuss the challenges of coverage and reconstruction in complex 3D scenes, presenting prediction-enhanced real-time coverage planning methods and heterogeneous drone collaboration strategies. Finally, we will explore recent advancements in transportation, delivery, and mobile manipulation.

Short Bio

Boyu Zhou is an Assistant Professor (Associate Researcher) at the Southern University of Science and Technology (SUSTech), where he serves as the Director of the Smart Autonomous Robotics (STAR) group. Boyu obtained his Ph.D. degree from the Aerial Robotics Group, Robotics Institute, at the Hong Kong University of Science and Technology in 2022, where he was awarded the HKUST Academic Excellence Award. He received his B.Eng. degree from Shanghai Jiao Tong University in 2018, graduating as an Outstanding Graduate in Shanghai. His research interests encompass aerial and mobile robots, motion planning, autonomous exploration, dense mapping, 3D reconstruction, and multi-robot systems. Boyu has published papers in prestigious robotics journals and conferences, including TRO, RAL, ICRA, IROS. His team's work has been recognized with the 2023 IEEE Transactions on Robotics Best Paper Award, the 2023 IEEE RAL Best Papar Award, and was a finalist for the 2024 IEEE ICRA Best Paper Award on Unmanned Aerial Vehicles. His publications have been listed as popular papers in TRO and RAL, with the highest ranking of No. 1. The research results have been reported by well-known technology media, such as IEEE Spectrum, Tech Xplore, etc.