IEEE ICMA 2026 Conference

Plenary Talk 1

Human Centered Autonomy

Henrik Christensen, Ph.D., Dr. Techn. h.c.

Distinguished Professor and Director of Robotics

Contextual Robotics Institute

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https://cri.ucsd.edu

Abstract:

The push for full replacement of human labor is challenged by uncertainty and a lack of structure in our daily lives. A more realistic vision is to consider how automation can be leveraged to empower humans in their daily life, such as work functions, mobility to/from work, and assistance with challenging tasks, such as heavy lifts or long walks. Through designs that are primarily about empowering humans, it is possible to achieve more effective systems. In this presentation, we will discuss multiple approaches to the design of automation that empower people in new ways, do this at a reduced cost of deployment, and achieve significant savings for the overall system. We will both discuss the overall design decisions, the underlying mechanisms/control and give examples of use of such systems in warehousing and in micro mobility. Finally, we will out several opportunities for the future.

Henrik I Christensen is the Qualcomm Chancellor's Chair of Robot Systems and the director of the Contextual Robotics Institute at UC San Diego. He directs the Cognitive Robotics Laboratory and the Autonomous Vehicles Laboratory. His research focuses on a systems approach to robotics, incorporating a theoretical foundation, solid implementation, evaluation in realistic settings, and translation to real-world applications.

Dr. Christensen has co-founded six companies, including Robust.AI, Intelligent Machines, and Christensen Consulting Group. He also co-founded Robo-Global, an international investment company that was acquired by Vetta Fi in 2022. He is an advisor to multiple venture companies such as InterWoven, Spring Mountain Capital, Calibrate Ventures, and Temasek International.

Henrik has published more than 400 contributions across robotics, computer vision, and AI, and has served on the editorial board of many journals such as Autonomous Robots, IJRR, IEEE Field Robotics. He is the main editor of the US National Robotics Roadmap. He is also an advisor to companies and government agencies across four continents.

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Plenary Talk 2

Industrial Exoskeletons: Health, Safety and Productivity in the Workplace of the Future

Prof. Darwin G Caldwell, FREng FIEEE MAE CEng
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Vice President IEEE RAS (Robotics and Automation Society)
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Abstract:

In the 18th century Bernardino Ramazzini, in his treatise “De Morbis Artificum Diatriba” (Diseases of Workers), suggested methods to prevent injuries in over 50 work environments. Ensuring worker health and safety is now deeply embedded, yet the World Health Organization estimates that over 1.7 billion people suffer from Work Related

Musculo-Skeletal Diseases (WRMSD). This impacts not only workers in obvious areas such as heavy lifting (Manual Material Handling), but ranges from manufacturing, construction and logistics to office and shop workers and even healthcare professionals. Every year >40% of workers suffer lower back or neck/shoulder pain, making WRMSD the leading cause of work-related health problems. This impacts: workers, employers, and society in general, due to sickness absence, injuries and disability, increased costs, higher employee turnover, and lower productivity. These injuries can have a lifelong debilitating effect. The EU estimates 2% of GDP is lost due to WRMSDs.
This presentation will explore the background to WRMSDs, and the global development of industrial/occupational exoskeletons for manufacturing, transportation systems, construction, logistics, and healthcare. Subsequently, I will focus on exoskeletal and wearable technologies developed at IIT, exploring the factors (hardware, software, HRI, intent recognition etc.) influencing design and effective real-world operation and deployment. Finally, I shall consider the future need and potential of this critical technology.

Prof. Darwin G Caldwell is Founding Director of the Italian Institute of Technology (IIT) in Genoa Italy, and Director of the Dept. of Advanced Robotics (ADVR) at IIT. He has pioneered developments in compliant and variable impedance actuation, Soft and Human Friendly Robotics and the creation of 'softer', safer robots, that draw on developments in materials, mechanisms, sensing, actuation and software. These developments have been fundamental to advances in humanoids, quadrupeds, medical robotics and exoskeletons. Key robots developed by his team include: iCub, a child-sized humanoid robot; COMAN, a controllably compliant humanoid designed to safely interact with people and have more natural (loco)motion; WALK-MAN, a 1.85m tall, 120kg humanoid that competed in the DARPA Robotics Challenge; the HyQ series (HyQ, HyQ2Max, HyQ-Real) of high performance hydraulic quadrupedal robots; and PHOLUS/Centauro, a human-robot symbiotic system capable of robust locomotion and dexterous manipulation in rough terrain and harsh environments. In addition to his research in legged robots, Prof. Caldwell also works extensively to develop wearable and haptic systems including whole body exoskeletons such as the XoSoft, XoTrunk, XoShoulder and XoElbow and in surgical and rehabilitation robotics where his team have developed systems such as the CALM (Computer Aided Laser Microsurgery) systems, the Cathbot, Cathbot-Pro and SVEI (for catherization and tissue type detection) and the Arbot (Ankle rehabilitation robot).
Prof. Caldwell is or has been an Honorary professor at the Universities of Manchester, Sheffield, Bangor and King's College London in the UK, and Tianjin University and Soochow University in China. He has published over 750 papers, has over 25 patents and has received over 50 awards/nominations at international conferences and events. He is a Fellow of the Royal Academy of Engineering (FREng - British National Academy), the IEEE (FIEEE), a Member (Fellow) of the Academia Europaea, a Fellow of the Asia-Pacific Artificial Intelligence Assoc. (FAAIA) and a Chartered Engineer (CEng). He is Vice President of the IEEE RAS (Robotics and Automation Society).

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Plenary Talk 3

Robotics and Automation in the Microscopic World for Biomedical Innovations

Fumihito Arai

Professor

Department of Bioengineering

Department of Mechanical Engineering

The University of Tokyo

http://www.biorobotics.t.u-tokyo.ac.jp/index_e.html

Abstract:

In scientific research, there is a growing need for manipulation and automation of micro- and nano-scale objects. Particularly in the biomedical field, genetic analysis technology is advancing rapidly, and the objects to be analyzed are now at the single-cell level. For analytical purposes, this scale is frequently employed in scientific research, such as investigating unknown properties of living cells and tissues. It requires precise manipulation techniques that account for interactions with the fluid environment of the sample being analyzed. We are working on robotics to expand capabilities in the microscopic world for biomedical innovations. Micro-nano mechatronics plays a crucial role in enabling new functions. Based on this approach, we investigated new capabilities of integrating robotic and Micro-nano mechatronics and applied them to several tasks. We developed the associated technologies required for automating micro and nano works. Furthermore, microscopic manipulation is also crucial during tissue sampling within the body. For example, tissue sampling within the digestive system may be considered. This is closely related to the non-invasive surgical operations. In this talk, emerging robotic technologies that expand capabilities in the microscopic world, particularly in manipulation and automation at small scales in the biomedical field will be introduced.

Fumihito Arai is a full Professor of the Department of Bioengineering, Department of Mechanical Engineering, at The University of Tokyo, Japan. He is mainly engaging in the research fields of bio-robotics, micro- and nano-robotics, micro- and nano-mechatronics, MEMS, and Biomedical applications. He received a Doctor of Engineering degree from Nagoya University in 1993. Since 1998, he has been an Associate Professor at Nagoya University. Since 2005, he has been a Professor at Tohoku University. Since 2010, he has been a Professor at Nagoya University. Since 2020, he has been a Professor at the Department of Mechanical Engineering at The University of Tokyo.

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Keynote Speech 1

Energy Harvesting Mechanism of the Oscillating Hydrofoil Tidal Energy Harvesting Device

Xu Jianan, Ph.D.

Professor and Dean

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Harbin Engineering University, China

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Abstract:

The development and utilization of ocean energy represent one of the most pressing research priorities globally today. This talk will introduce our research progress on the fully passive oscillating hydrofoil tidal energy harvesting device under coupled motion mode. This device offers advantages such as adaptability to low flow velocities, environmental friendliness, and excellent environmental adaptability.

The talk will first outline the current state of research on ocean energy harvesting devices. Building upon this foundation, it will focus on introducing the design philosophy and energy harvesting performance advantages of our proposed fully passive oscillating hydrofoil tidal energy harvesting device. Furthermore, by integrating a novel fluid-structure interaction analysis method we have developed, the report will provide an in-depth analysis of the device's energy harvesting performance and the underlying fluid-structure interaction mechanisms. Experimental results will be presented to demonstrate the device's actual operation.

Xu Jianan, Ph.D., Full Professor. Dean of the College of Mechanical and Electrical Engineering at Harbin Engineering University. Director of the Key Laboratory of Special Ship Auxiliaries and Underwater Equipment under the Ministry of Industry and Information Technology; Chairman of the Ship and Offshore Engineering Branch of the China Industrial Design Association; Member of the National Technical Committee for Marine Standardization. His research focuses on the marine mechatronics system, ocean energy harvesting system, and the wave compensation system.

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Keynote Speech 2

Development of Biomimetic Dynamic Robots

Aiguo Ming, Ph.D.

Professor

Robotics and Mechatronics Lab

Department of Mechanical Engineering and Intelligent Systems

The University of Electro-Communications, Tokyo, Japan

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Abstract:

In this talk I will describe our progress on the development of two types of biomimetic robots: (1) Biomimetic hyperdynamic robots and (2) Soft biomimetic robots.

The first part of the talk will focus on the mechanism and motion control skill commonly used by humans and animals but mostly avoided by conventional robots, such as utilization of joint stop mechanisms and dynamically-coupled driving in hyper dynamic motions. These issues exploit the nonlinear mechanisms and dynamics to realize natural hyperdynamic motions by a smart structure.

In the second part of the talk I will describe our work on how to introduce creatures' structure and propulsion mechanism into soft robots to realize high mobility, efficiency 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.). I will show our basic approach toward the synergy and some examples of the developed soft biomimetic 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.).

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, at The University of Electro-Communications (UEC), Tokyo, Japan. Dr. Ming is an editor of International Journal of mechatronics and Automation and was an editor of the International Journal of Robotics. His current research interests include biomimetic hyperdynamic robotics, soft biomimetic robotics, robotic hands with proximity sensors, and precise gear measurement systems.