IEEE ICMA 2025 Conference

Plenary Talk 1

Intelligent Robotic System with Machine Learning

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Abstract:

Recent robot technology (RT) has made remarkable progress in both manufacturing and service sectors. Because of this RT advanced technology, there are growing demands to make robots work more friendly and flexible coordinated with human for service. There are many research and developing works undergoing for robot and human interaction, such as assistance and supports of human by robots in manufacturing, inspection and maintenance, entertainment, education, bio-medical applications, rehabilitation and techno-care of aged people. Robot is required to have the more flexibility and adaptation control to human behavior, more friendly robot and human interface, and estimation capability of human intention some way to make more proactive motion. There are a lot of problems to solve them with robotic sensor, actuator, control, communication and interface with human.

This talk is an overview of the Multi-scale robotics, based on the Cellular Robotics System, which is the basic concept of the emergence of intelligence in the multi-scale way from Organizational Level, Distributed robotics to Biological Cell engineering and Nano-robotics, which was proposed more than 30 years ago. It consists of many elements how the system can be structured from the individual to the group/society levels in analogy with the biological system. It covers with the wide range of challenging topics, but intelligent robotics is focused in this talk:

1. Distributed autonomous robotic system
2. Cooperation and competition of the multiple robotics system
3. Individual robot level, Brachiation Robots and Multi-locomotion robots,
4. Medical robotics and simulator,
5. Micro and nano robotics system
6. Bio analysis and bio-synthesis: bio-robotics system
7. Cyborg and Bionic System
8. Other systems.

Then I mainly focus on Robotics and AI and refer to applied areas for the future hybrid system to improve the quality of life of human.

Toshio Fukuda (M'83-SM'93-F'95) graduated from Waseda University, Tokyo, Japan in 1971 and received the Master of Engineering degree and the Doctor of Engineering degree both from the University of Tokyo, in 1973 and 1977, respectively. He studied at Graduate School of Yale University in 1973-1975. He joined the National Mechanical Engineering Laboratory in Japan in 1977, the Science University of Tokyo in 1982, and then joined Department of Mechanical Engineering, Nagoya University, Japan in 1989. He worked at University of Stuttgart, as Humboldt Fellow in 1979-1981.

He is Professor Emeritus of Nagoya University and Professor of Meijo University and Waseda University. He has been working as Professor of Shenyang University of

Technology, Suzhou University, Institute of Automation, Chinese Academy of Science, Russell Springer Chaired Professor at UC Berkeley, Seoul National University, Advisory Professor of Industrial Technological Research Institute in Taiwan and etc. He is a Foreign member of Chinese Academy of Sciences (2017).
He is mainly engaging in the research fields of intelligent robotic system, micro and nano robotics, bio-robotic system, and technical diagnosis and error recovery system.

He was the President of IEEE Robotics and Automation Society (1998-1999), Director of the IEEE Division X, Systems and Control (2001-2002), the Founding President of IEEE Nanotechnology Council (2002-2005), Region 10 Director (2013-2014), Director of Division X, Systems and Control (2017-2018) and IEEE President (2020). He was Editor-in-Chief of IEEE/ASME Trans. Mechatronics (2000-2002).

He was the Founding General Chair of IEEE International Conference on Intelligent Robots and Systems (IROS) held in Tokyo (1988). He was Founding Chair of the IEEE Conference on Nanotechnology(2001), IEEE Workshop on Robot and Human Communication (1994), IEEE Workshop on Advanced Robotics Technology and Social Impacts (ARSO, 2005), Founding Chair of the IEEE Workshop on System Integration International (SII, 2008), Founding Chair of the International Symposium on Micro-Nano Mechatronics and Human Science (MHS, 1990-2012), IEEE Conference on Cyborg and Bionic Systems(2017), IEEE Conference on Intelligence and Safety of Robots (2018).

He has received many awards such as IEEE Eugene Mittelmann Achievement Award (1997), IEEE Third Millennium Medal (2000) , Humboldt Research Prize (2003), IEEE Robotics and Automation Pioneer Award (2004), IEEE Transaction Automation Science and Engineering Googol Best New Application Paper Award (2007), George Saridis Leadership Award in Robotics and Automation (2009), IEEE Robotics and Automation Technical Field Award (2010). He received the IROS Harashima Award for Innovative Technologies (2011), Friendship Award of Liaoning Province PR China (2012), Friendship Award from Chinese Government (2014), JSME Achievement Award (2015), IROS Distinguished Service Award (2015) and Honor of Medal with the Purple Ribbon from Japanese Government (2015). Award from Automation Foundation (2016), Chunichi Culture Award (2019).

IEEE Fellow (1995). SICE Fellow (1995). JSME Fellow (2002), RSJ Fellow (2004), VRSJ Fellow (2011) and member of Science Council of Japan (2008-2014), and Academy of Engineering of Japan (2013-).

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Plenary Talk 2

Model Driven Mechatronics in Medical Robot Design

Blake Hannaford, Ph.D.

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Abstract:

Development of robotic technology for medical application is a complex endeavor. Engineers with little or no formal medical training must understand highly evolved medical requirements as well as the state of the art in robotics engineering. The standard for accepting a new medical innovation prior to use in the clinic is extremely rigorous. In light of these challenges, even in the more relaxed constraints of research devices, model driven design and control engineering is required to supplement highly evolved and rigorously trained human skills. Lacking a general theory of models in medical robotics, this talk will introduce the use of models in medical robot system control and design through examples from the work of our students and collaborators.

Blake Hannaford received the B.S. degree in Engineering and Applied Science from Yale University in 1977, and the M.S. and Ph.D. degrees in Electrical Engineering from the University of California, Berkeley. From 1986 to 1989 he worked on the remote control of robot manipulators in the Man-Machine Systems Group in the Automated Systems Section of the NASA Jet Propulsion Laboratory, Caltech and supervised that group from 1988 to 1989. Since September 1989, he has been at the University of Washington in Seattle. He was awarded the National Science Foundation's Presidential Young Investigator Award, the Early Career Achievement Award from the IEEE Engineering in Medicine and Biology Society and was named IEEE Fellow in 2005.

He was at Google X / Google Life Sciences from April 2014 to December 2015. His currently active research interests include surgical robotics, surgical skill modeling, and haptic interfaces.

Blake Hannaford, Ph.D., is Director of Technical Programs and the University of Washington's, Global Innovation Exchange (GIX), and Professor of Electrical & Computer Engineering, Adjunct Professor of Bioengineering, Mechanical Engineering, and Surgery at the University of Washington.

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Plenary Talk 3

Microrobotics and Nanomedicine: Future Directions in Medical Robotics

Bradley Nelson, Ph.D.

Professor, ETH Zurich

Head of Department of Mechanical and Process Eng.

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ETH Zurich, Switzerland

Abstract:

While the futuristic vision of micro and nanorobotics is of intelligent machines that navigate throughout our bodies searching for and destroying disease, we have a long way to go to get there. Progress is being made, though, and the past decade has seen impressive advances in the fabrication, powering, and control of tiny motile devices. Much of our work focuses on creating systems for controlling micro and nanorobots as well as pursuing applications of these devices. As systems such as these enter clinical trials, and as commercial applications of this new technology are realized, radically new therapies and uses will result that have yet to be envisioned.

Prof. Bradley Nelson has been the Professor of Robotics and Intelligent Systems at ETH Zürich since 2002. He has over thirty years of experience in the field of robotics and has received a number of awards in the fields of robotics, nanotechnology, and biomedicine. He serves on the advisory boards of a number of academic departments and research institutes across North America, Europe, and Asia and is on the editorial boards of several academic journals. Prof. Nelson is the Department Head of Mechanical and Process Engineering at ETH and has been the Chairman of the ETH Electron Microscopy Center and a member of the Research Council of the Swiss National Science Foundation. He also serves on boards of three Swiss companies. Before moving to Europe, Prof. Nelson worked as an engineer at Honeywell and Motorola and served as a United States Peace Corps Volunteer in Botswana, Africa. He has also been a professor at the University of Minnesota and the University of Illinois at Chicago.

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Keynote Speech

Nano-Tactile Sensors for Visualization of Texture: Achieving Super-Human Performance via Deep Learning

Hidekuni Takao, Ph.D.

Professor and Director

Nano/Micro Structure Device Integrated Research Center

Kagawa University

https://researchmap.jp/read0057664?lang=en

Abstract:

In this talk, recent advances in state-of-the-art tactile sensing technology for precise visualization of tactile textures are introduced. Using MEMS technology, we developed "nano-tactile sensors" that emulate human fingertip functionality, achieving tactile data acquisition at resolutions below 10 μm, significantly surpassing human sensitivity. By applying deep learning to high-density tactile data, we created a tactile sensing platform exceeding human perception. The sensors effectively distinguish tactile characteristics of materials such as metals and fabrics, enabling quantitative evaluation of hair cuticle structures for damage assessment and detailed hardness mapping of skin and tissues at approximately 100 μm resolution. Such data are invaluable for clinical diagnostics and healthcare applications. Additionally, deep learning algorithms detect subtle differences imperceptible to human touch. For example, the system identified 14 tissue paper types with over 95% accuracy and estimated market values within a 25% error margin, exemplifying "super-human" tactile capabilities. This advanced technology holds great promise as an innovative tool for various robotics applications, including medical, precision manufacturing, and caregiving fields.

Hidekuni Takao was born in Kagawa, Japan, in 1970, and received his Ph.D. from Toyohashi University of Technology in 1998. He is currently the Director and professor of the Nano-Microstructure Device Integration Research Center at Kagawa University. His research focuses on ultra-high-performance tactile sensors and their applications to pioneering new fields. He has been serving as the Principal Investigator of two JST-CREST projects since 2015. His contributions have been acknowledged through several awards, including the Commendation for Science and Technology by the Japanese Minister of Education, Culture, Sports, Science and Technology (2023), the CEATEC AWARD 2023 Grand-Prix (2023), and the 24th Yamazaki-Teiichi Prize (2024). In addition to his academic achievements, Prof. Takao actively serves the professional community as a Director of the Institute of Electrical Engineers of Japan (IEEJ) and the Chair of the IEEJ Shikoku Branch, and so on.