IEEE ICMA 2024 Conference

Keynote Speech 1

AI-Powered Surgical Robots

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Abstract:

Surgical robotics is one of the most successful realms in robotics, distinguished by its highly active research community, exceptional benefits to healthcare system and remarkable economic gains. Extensive surgical robots, such as the da Vinci surgical system, etc., are manually controlled by surgeons to carry out the procedures. With the recent rapid advancement of Artificial Intelligence (AI) technologies, it is widely believed that such

tele-controlled robots will be replaced by next-generation AI-powered surgical robots that could autonomously perform surgical sub-tasks or the entire procedures. Under the support of Hong Kong Research Grant Council, we have been carrying out a 10-year research project on autonomous surgical robots, which aims at developing the fundamental technologies that lay the foundations for such autonomous surgical robots, namely AI-based perception of surgical objects and surgical field, AI-powered surgical planning and navigation based on multi-modal data fusion, surgical skill learning from expert data, and data-driven control. The technologies are also being integrated into systems, which are to be validated by experiments. This talk will introduce the project, the results we have obtained, the on-going tasks, and the future research work.

Yun-hui Liu received B. Eng. degree in Applied Dynamics from Beijing Institute of Technology, M. Eng. degree in Mechanical Engineering from Osaka University, and Ph.D. degree in Applied Mathematics from the University of Tokyo. After working at the national Electrotechnical Laboratory of Japan as a Research Scientist, he joined The Chinese University of Hong Kong (CUHK) in 1995 and is currently Choh-Ming Li Professor of Mechanical and Automation Engineering, the Director of the CUHK T Stone Robotics Institute, and the Director/CEO of Hong Kong Centre for Logistics Robotics funded by the InnoHK clusters of the HKSAR government. He has published more than 500 papers in refereed journals and conference proceedings and was listed in the Highly Cited Authors (Engineering) by Thomson Reuters in 2013. His research interests include vision-based robotics, machine intelligence and their applications in manufacturing, logistics, healthcare and constructions. Prof. Liu has received numerous research awards from international journals and international conferences in robotics and automation, and from government agencies. In recent years, he has been actively transferring robotics technologies developed at university labs to industries, and co-founded VisionNav Robotics, CornerStone Robotics, etc. He was the Editor-in-Chief of Robotics and Biomimetics and served as an Associate Editor of the IEEE TRANSACTION ON ROBOTICS AND AUTOMATION. He is Fellow of IEEE, HKIE and HKAES.

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Keynote Speech 2

Evaluation of Robot Intelligence Level

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Abstract:

Robot intelligence is evaluated based on five essential elements, including perception, cognition, decision-making, execution, and interaction. The intelligence of a robot can then be classified into five levels, from L1 to L5, according to the implementation of the five elements. This talk is on the procedure of robot intelligence level evaluation. First, the test items are selected according to the intelligent characteristics and attributes of the sample. Next, according to the standard of robot intelligence level, tests are conducted separately on the five elements. Among the elements, perception includes visual, auditory and tactile

senses; cognition and decision-making include path planning, path adaptation, trajectory planning, trajectory adaptation, et al. Execution ability is evaluated by movement accuracy, force control accuracy as well as motion accuracy. While interaction includes human-robot interaction, operation interaction, and multi-robot interaction. Based on the above tests, the ability assessment covering the five elements are conducted and the intelligence level is determined under comprehensive evaluation.

Junqi Zheng graduated from East China University of Science and Technology in 1998. He is currently the Vice President of Shanghai Electrical Apparatus Research Institute, the President of Shanghai Robot Industrial Technology Research Institute, and the Director of National Robot Test and Assessment Center (Headquarters). He is also the Vice Chairman of International Electrotechnical Commission/ CISPR, the Secretary General of National Technical Committee on Radio Interference of Standardization of China, and the leader of CCC Certification Electromagnetic Compatibility (EMC) Expert Group in Certification and Accreditation Administration of the People's Republic of China (CNCA). He is also the head of Shanghai Robotics Functional Platform of R&D and Achievement Transformation. He was the chief designer of the National Robot Test and Assessment Center.

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Keynote Speech 3

Advancing Big Data Storage System by Artificial Intelligence

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Professor

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Abstract:

In the Big Data era, we are surrounded by digital products and digital technology. The necessity for large-capacity storage equipment has increased. holographic data storage system has been good candidate for volumetric recording technologies. However, the noise of reconstructed image and environment vibrations are the big problems to limited the advantages of holographic data system. Collinear Holography with a servo system can realize the commercialization of holographic data storage, because of its unique configuration. In this paper, we introduced the principle of the Collinear Holography and its media structure for the servo. We also discussed some methods to increase the recording density and data transfer rates by using artificial intelligence.

Xiaodi Tan graduated from the Optical Department of Shandong University in 1984, he obtained Master‘s Degree from the Optical Engineering Department of the Beijing Institute of Technology in 1990. His Doctoral thesis was completed at The University of Tokyo, Institute of Industrial Science in 2001. He was a Senior Engineer of the Technology Division in OPTWARE Corporation, researching and developing the next generation of optical data storage systems. And he was a Senior Technology Analyst, Distinguished Engineer and Optical Technology Manager of Core Device Development Group in Sony Corporation. During 2012 to 2017, he was a professor at the School of Optoelectronics in Beijing Institute of Technology. He is currently a professor at the College of Photonic & Electric Engineering in Fujian Normal University, the Director of Information Photonics Research Center. His is the Fellow of International Society of Optical and Photonics (SPIE) and Optical Society of America (Optica), the Director of Chinese Society of Optical Engineering (CSOE) and the Chinese Optical Society (COS). His research interests are in information optics & photonics: holographic storage, optical information display, optical devices, etc.

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Plenary Talk 1

Image Harmonization and Airway Tree Subtyping on Large Cohorts of CT Scans of the Lung for COPD Risk

Andrew F. Laine, D.Sc.

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Bio-Sketch:

Andrew F. Laine received his D.Sc. degree from Washington University (St. Louis) School of Engineering and Applied Science in Computer Science, in 1989 and BS degree from

Cornell University (Ithaca, NY). He was a Professor in the Department of Computer and Information Sciences and Engineering at the University of Florida (Gainesville, FL) from 1990-1997. He joined the Department of Biomedical Engineering in 1997 and served as Vice Chair of the Department of Biomedical Engineering at Columbia University since 2003 – 2011, and Chair of the Department of Biomedical Engineering (2012 – 2017). He is currently Director of the Heffner Biomedical Imaging at Columbia University and the Percy K. and Vida L. W. Hudson Professor of Biomedical Engineering and Professor of Radiology (Physics).

He has served on the program committee for the IEEE-EMBS Workshop on Wavelet Applications in Medicine in 1994, 1998, 1999, and 2004. He was the founding chair of the SPIE conference on "Mathematical Imaging: Wavelet Application in Signal and Image Processing" and served as co-chair during the years 1993-2003. Dr. Laine has served as Chair of Technical Committee (TC-BIIP) on Biomedical Imaging and Image Processing for IEEE EMBS 2004-2009 and has been a member of the TC of IEEE Signal Processing Society, TC-BISP (Biomedical Imaging and Signal Processing) 2003-present. Professor Laine served on the IEEE ISBI (International Symposium on Biomedical Imaging) steering committee, 2006-2009 and 2009 – 2012. He was the Program Chair for the IEEE EMBS annual conference in 2006 held in New York City and served as Program Co-Chair for IEEE ISBI in 2008 (Paris, France). He served as Area Editor for IEEE Reviews in BME in Biomedical Imaging since 2007-2013. He was Program Chair for the EMBS annual conference for 2011 (Boston, MA). Professor Laine Chaired the Steering committee for IEEE ISBI, 2011-2013, and Chaired the Council of Societies for AIMBE (American Institute for Medical and Biological Engineers). He was the General Co-Chair for IEEE ISBI in 2022. Finally, he served as the IEEE EMBS Vice President of Publications 2008 – 2012 and was the President of IEEE EMBS (Engineering in Biology and Medicine Society) 2015 and 2016. He currently serves as the Chair of the Membership Committee for IAMBE (International Academy of Medical and Biological Engineers). He is a Fellow of IEEE, AIMBE and IFMBE.

Abstract:

Chronic obstructive pulmonary disease (COPD) defined by irreversible airflow limitation, is the 3rd leading cause of death globally and 4th in the United States. Smoking tobacco is a major extrinsic COPD risk factor, but despite six decades of declining smoking rates in many countries, the corresponding declines in COPD have been modest. Only a minority of lifetime smokers develop COPD, and up to 25% occurs in never smokers. While other factors have been linked to COPD much of the variation in COPD risk remains unexplained.

Airflow obstruction, or reduced airflow from the lungs, is determined in part by airway tree structure and lung volume, both of which can be imaged with high precision by high resolution computed tomographic (HRCT) scans. Emerging evidence by our group suggests that airway tree structure variation is common in the general population and is a major

contributor to this unexplained COPD risk. By manual labeling of the airway tree structure, limited to one airway generation in just 2 of the 5 lung lobes (due to complexity of tree structure), we found that 26% of the general population has major airway branch variants that differ from the classical “textbook” structure, increase COPD risk, and have a strong and biologically plausible genetic basis. We further demonstrated that airway tree caliber variation (dysanapsis) measured on CT was a stronger predictor of COPD risk than all known risk factors including smoking. Yet there is no standardized approach to characterize the full scope airway tree variation, making the exact relationship between COPD and individual airway-structure features unclear.

This works applies the power of machine learning methods to the entire airway tree structure imaged on HRCT to build logically upon prior high-impact work to discover new COPD sub-phenotypes for risk stratification and biological pathways of intervention. Also, we apply sophisticated / rigorous mathematical clustering approaches to airway trees derived from over 18,000 computed tomography (CT) scans in three highly characterized cohorts – MESA Lung Study, SPIROMICS, COPDGene Study, in addition to CanCOLD – to discover and replicate novel and clinically significant airway tree subtypes and their genetic basis. By understanding airway tree structure subtypes from lung CT scans, we hope to advance our knowledge of disease susceptibility and improve personalized therapies, prognosis, and identify an underlying genetic basis to COPD risk

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Plenary Talk 2

New relationship between human and machine - machine with a heart

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Abstract:

Robots that play an active role in the human living environment are said to be preferably humanoid type. Above all, in order to move around in a human living environment optimized for humans, it is most important to have the same physical functions as humans, and it is also important not to require prior special knowledge from humans who work

together with robots. It would be convenient if we could communicate with the robot as a partner, ask for work, and grasp the state of the robot as if we were communicating with humans. Initially, humanoid research had a strong aspect of a way to know human, but recently, the realization of humanoids as practical robots is no longer a dream. The next may be a machine with a heart. I would like to talk about a machine with a heart and a recent AI, what is promising and what is not.

Shuji Hashimoto received the B.S., M.S. and Dr.Eng. degrees in Applied Physics from Waseda University, Tokyo, Japan, in 1970, 1973 and 1977, respectively.
He was an Associate Professor in the Department of Physics, Toho University from 1979. In 1991 he moved to Waseda University as a Professor of the Department of Applied Physics. In Waseda University he served as the Director of the Humanoid Robotics Institute for ten years from 2000. During 2006-2010 he was the Dean of Faculty of Science and Engineering. He served as the Senior Executive Vice President for Academic Affairs and Provost of the University from 2010 to 2018. His research interests include Artificial Intelligence, Robotics, "KANSEI" Information Processing, Sound and Image Processing and Meta-Algorithm. Currently he is Professor Emeritus at Waseda University. He is also one of the Leaders in the Gundam Global Challenge and a Director of XELA Robotics Co. Ltd. He was appointed the Vice President of Egypt Japan University of Science and Technology (E-Just) in 2023.

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Plenary Talk 3

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

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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 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).