Guest Editorial
Introduction to the Focused Section on Mechatronics and Automation for Constructions

I. Introduction

RAPID advances in modern technologies have completely revolutionized many industries in recent years. It is anticipated that mechatronic and automation technologies would play an important role in transforming the construction industry to embrace for the fourth industrial revolution. However, construction automation problems bring up new research challenges that diverge from traditional methods. Unlike the factory environment, which is typically structured and predictable, construction sites are dynamic places where the working environment is unstructured and always changing. Due to lack of skilled labor, time and cost overruns, quality deficiencies, and the recent pandemics, mechatronic and automation technologies offer solutions for future safe, rapid, performative, prize worthy, and digitally protocolled construction projects. The coexistence of human workers, heavy vehicles, varying environmental conditions, and automated mechatronic systems also make safe human–machine interaction an important issue. Beyond expertise in a specific discipline, construction automation also requires multidisciplinary expertise to integrate with various fields, such as Internet of Things (IOT), robotics and its construction oriented subsystems, adaptive/robust control, machine vision, sensing technologies, artificial intelligence (AI), and building/construction/process information modeling (BIM/CIM/PIM) for automated construction process management and design. The main aims of this focused section in the IEEE/ASME Transactions on Mechatronics (TMECH) are to document the current state of the art in mechatronics and automation for constructions, and to present new results in several emerging research areas.

II. Recent Progress on Mechatronics and Automation for Constructions

Mechatronics and automation in construction at present makes tremendous progress in a multitude of scientific areas. In the following, we exemplarily highlight selected key areas.

A. Perception Technologies in Intelligent Construction

With the advent of Industry 4.0, the new generation of perception technologies such as laser radar, machine vision, and AI would be widely applied in construction automation.

Digital Object Identifier 10.1109/TMECH.2021.3127237

The perception technology in construction industry includes the perception of the working status of the machinery and the construction sites. To improve the quality and efficiency of construction, much research work has been developed based on different engineering scenarios. Yuan *et al.* [A1] developed a stereo vision system to detect and track the operating status of excavators by extracting mixed motion patterns and key node features, so as to improve the control accuracy. Motivated by the recent success of deep convolutional neural networks (CNNs) in image recognition, Liang *et al.* [A2] built a CNN to train a set of construction images and obtained the robot's 2-D pose information. The stacked hourglass network was used to predict and reconstruct 3-D pose information, which was more accurate than the traditional sensor measurement. In addition, the environment perception also plays an important role in intelligent construction. For example, in the operations of remote-controlled cranes and unmanned transportation equipment, information of the operated objects and construction sites is required. Li and Ding [A3] adopted a 3-D laser scanner to establish a 3-D image of the crane cargo handling, and combined it with an optimization method to automatically generate the cargo handling sequence. Therefore, automatic handling of large quantities of cargoes can be realized. Bouton *et al.* [A4] designed a wheel-on-leg robot that can be used in uneven terrain. The output force of the elastic actuation on each leg was controlled based on the contact pressure measured by a force sensor, so that the robot can freely balance its posture to adapt to complex terrain. Yoo and Kim [A5] adopted an on-board 2-D laser scanner to build a 3-D local terrain system. The local model was updated with the changing construction sites. Lei *et al.* [A6] applied AI technology to the operational status and environmental perception of excavator. Visualization of the on-site data, fault diagnosis and prediction are then carried out through data analysis.

In summary, the advances of perception technologies would promote construction automation greatly from the aspects of efficiency, performance, reliability, and construction processes' optimization. With the development of AI and new sensing technology, the advantages of intelligent construction would gradually be revealed.

B. Modularity for the Construction Sector

The modularity in robotics and mechatronics [A7] had played an important role in generating a flexible design consisting of scalable and reusable modules. Nowadays, one of the crucial design features in robotics and mechatronics is the modularity of components. The partitioning of a system in different functional units/modules, which interact with each other allows a reduction of cost due to the flexibility as well as reusable design of components. Moreover, modules offer the possibility of interoperability, a shorter learning time for users due to the similarity and adaptiveness of components and nongenerationally constrained augmentation or updating. The modules of a system are interdependent, connected via interfaces and can be reversibly separated in a defined manner. The concept of modularity in robot system architecture could be further extended to modular construction processes and modularly structured building products in the future.

C. Mechatronics, Robotics, and AI Technologies for Infrastructure Inspection and Maintenance

Mechatronics and automation technologies are utilized not only for construction of new civil infrastructures, but also for maintenance of old ones. Inspection is one of the most important tasks for infrastructure maintenance. Old infrastructures such as bridges and tunnels require periodic inspection. This means that infrastructure inspection is time-consuming and burdensome. Automation of inspection is an effective and essential way to solve this problem. The demand for infrastructure maintenance and inspection robotics is increasing [A8].

Inspections are basically performed in a nondestructive way such as visual inspection using a camera mounted on a robot. Robots are typically required to approach the inspection targets. Therefore, movement mechanism and mobility are important for inspection robots, and various mechanisms that can access difficult-to-reach areas have been proposed [A9], [A10]. Special mechanisms are sometimes needed according to the inspection targets and tasks. For example, pipe inspection robots need motion mechanisms to move inside the pipe [A11]. Bridge or tunnel inspection robots require the ability to access tall places. Unmanned aerial vehicles (UAV) have become popular due to the increase in performance of commercially available UAVs.

As to the inspection technologies, computer vision and machine learning techniques are widely used for damage or defect detection [A12], [A13]. Deep learning-based methods have shown high performance in many applications. However, it requires a large amount of data. There is a relatively large number of image dataset, but it is often difficult to collect dataset other than images, e.g., acoustic data for hammering test. It is therefore important to create a database of various formats and also include defects and abnormal conditions in addition to normal conditions, for construction automation.

D. Process Modeling as Basis for Further Robotic and Mechatronic Developments

The process modeling offers the possibility of describing a chronological sequence of activities in a higher level business process. It helps to clearly document processes to generate a deeper understanding of activities, functions, roles, and interfaces [A14].

After the process documentation (e.g., construction process with and without robot), a consecutive analysis can serve to identify system requirements and existing obstacles to innovation. The analysis can reveal weak points, point out optimization potentials, contribute to a high level of quality, support certification for standards, and, ultimately, transparently represent cost savings in the process. This synthesis of information can be used to evaluate the construction process and the innovation and efficiency potential.

In general, the construction process is determined by various processes of different stakeholders and responsibilities. In the process, there are various interfaces coexisting, which cause a complicated and tedious construction process. Moreover, there is no data basis of modeled processes that are combining the construction process with the robot as integral part of it. There is therefore an urgent need of detailed and modeled up construction processes with and without robotic/mechatronic systems.

Based on the process modeling, the effects of changes in any process, as well as process parameter, can be analyzed, tested, and evaluated to make the process more efficient and cost-effective.

E. Complexity Control Tactics

The terminology *robot-oriented design* (ROD) was defined by Bock *et al.* [A15] and it describes a holistic approach, which suggests an integration of new technologies (such as robotics) to the construction industry to ensure efficient as well as rapid on-site assembly operations and a reliable product performance throughout the whole lifecycle.

To achieve this integration/management, the approach calls for a co-adaption of construction products, processes, organization, management, and automated/robotic/mechatronic technology enabling an easier and more efficient implementation of modern technology. New technologies (such as ICT, microsystem technology, automation, mechatronics, robotics, and others) could transform the construction sector and lead to an innovation of traditional processes.

In general, if products are not properly processed on-site, then that can cause major quality issues. Robotics guarantees the same quality of products even on the construction site. Nowadays, there are already new technologies being applied in the construction of buildings as well as their lifecycle management. Construction tasks such as brick layering, wall painting or plastering, drilling or on-site inspections by drones, exoskeletons for lifting heavy loads, or even concrete 3D-printing for printing the entire building shell are executed by robots and partially applied on-site.

In summary, the construction sector has already benefitted and executed the ROD-approach with further developments in robotic and mechatronic applications to increase the resource efficiency and performance of any construction or building product or process through the whole lifecycle, but still needs to improve the overall integration of new management, production, and product strategies.

III. Highlights in This Focused Section

Although there have been many contributions to the research and development of mechatronics and automation for constructions, many emerging research areas and applications remain to be explored. This focused section brings together six articles to highlight some of the recent developments in this area.

Concrete is a basic material that is widely used in modern construction. The traditional method for inspection of defects in concrete structures is typically based on the manual hammering test. With recent advances in machine learning techniques, supervised learning approaches based on training data can be used to automate the process. However, these methods rely heavily on the availability and quality of the training data. Weakly supervised learning can be used to alleviate this problem but existing works in this field still require a large amount of weak supervision provided by humans. The first article by Jun *et al.* [A16] proposes a novel weakly supervised augmentation method for defect detection in concrete structures. The main aim is to achieve high defect detection performance with a low amount of weak supervision provided by humans. The results were verified by experiments conducted in field conditions.

One obvious limitation of the hammering test is that the fault detections are limited to the areas of the concrete structures that are reachable by the inspectors. In many modern structures such as high-rise buildings, it is difficult to cover all areas extensively by the hammering test. The article by Chun and Hayashi [A17] aims to overcome this problem by developing a novel method for automatic detection of floating and delamination of concrete structures based on infrared thermography. A detection system is developed for inspection without any physical contact with the concrete structures. The proposed system has been implemented and tested in various structures located in Japan and the United States. The authors believe that the proposed method would fundamentally change the inspection method of concrete structures.

Vision system is an important part of the mechatronic or robotic systems in construction automation. Current state-of-the-art techniques for object recognition are based on deep neural networks such as CNN. After training a deep neural network model with a suitable dataset, it can be used to classify various classes of objects accurately. One limitation of the deep learning-based approach is that it is a data-driven method where the detection accuracy is dependent on the availability of large training datasets and the performance is fixed after the training process. To enhance performance for real-time detection in construction sites, Ilyas *et al.* [A18] propose a robot-assisted object-detection approach by leveraging on the BIM information and robot mobility. Toward achieving this aim, several novel approaches such as BIM-based object coverage navigation algorithm and BIM-based false detection filtering technique are proposed. Experimental results are presented to illustrate the performance.

In construction work, the performance of human-operated machines is dependent on several factors such as the expertise of the operators, the specifications of the machines, and the interface between human and machines. To improve work performance of human–machine systems, Kamezaki *et al.* [A19] introduce the concept of basic input–output gain (BIOG) and develop an automatic tuning or learning method to adjust the gain. Unlike conventional gain adjustment methods, the proposed methodology aims to adapt to global trends based on long-term data rather than local saliency. Experimental results based on a human-operated hydraulic arm are presented.

Hydraulically powered machines are commonly used in construction sites. One important factor toward automating these machines is the development of automatic controllers. In the article by Fan and Li [A20], a novel adaptive fuzzy controller based on hybrid cerebellar model articulation control method is developed for electro-hydraulic shovels. The proposed method requires only the measurement of position data and stability analysis of the control system is presented.

The process of digitalization in construction automation requires the development of various digital models and the processing of huge amount of information from multiple data sources with different formats. The article by Takeyama *et al.* [A21] describes the development a software system that utilizes a data processing platform to process and integrate data, so as to generate mediated data that conform to the same structure. Based on the mediated data, various analytical models can therefore be automatically generated for analyses. A case study showing how a 3-D ground grid model can be constructed and updated based on borehole data obtained from ground surveys is presented in this article.

IV. Conclusion

Whereas the development and integration of information-driven technology for on-site construction such as BIM, scheduling and construction process optimization techniques, sensing systems, and UAV-dominated research and development activities in the area of on-site focused construction automation and robotics for over a decade, recently a renewed interest in the development of mechatronics-based and physical–mechanical robot systems for the execution of tasks on the construction site can be observed. This manifests itself in an increase in academic research activity, joint industry–academia collaboration projects, the emergence of start-ups (e.g., Bunkeberg Systems AB, n-Link, Fastbrick Robotics, O-Matic Intelligent Robot Ltd., Construction Robotics, Autonomous Solutions Inc., Kewazo, Built Robotics, Levaru, OutoBot, ROB Technologies, Tmsuk Co. Ltd., Constructions-3D, German Bionic, Okibo, etc.), and a strong and growing interest of large, established organizations (e.g., Construction Industry Council Hong Kong, Excellence Group, Bouygues Construction, Thyssenkrupp, Country Garden Group, Hilti AG, Takenaka Corporation, Hitachi Construction, Hip Hing, Yau Lee, Züblin, Boston Dynamics, Glodbeck, etc.) toward the development of construction robots.

The recent pandemic has accelerated the adoption of technologies in many industries. However, construction sites are dynamic places where the working environment is unstructured and always changing. Different work environment and requirements at various stages of construction pose a huge challenge for full deployment of mechatronic or robotic technologies at economic scales. A complete mechatronic construction solution also requires the integration with existing construction machines and considerable effort in standardization. With the growing interest from academics and companies, and increasing support from government organizations, the research and development of mechatronics and automation in construction is set to grow.

Acknowledgment

The guest editors would like to thank all the contributing authors for submitting their latest research results to this Focused Section. Additionally, they also express appreciation to all reviewers for their hard work and great support. They would also like to extend special thanks to Prof. I-Ming Chen, Editor-in-Chief of the IEEE/ASME Transactions On Mechatronics, for the opportunity to organize this Focused Section.

Chien Chern Cheah, *Lead Guest Editor*
School of Electrical and Electronic Engineering
Nanyang Technological University
639798 Singapore

Thomas Bock, *Co-Lead Guest Editor*
Chair of Building Realisation and Robotics
Technical University of Munich
80333 Munich, Germany

Jianfu Cao, *Guest Editor*
Institute of Automatic Control
Xian Jiaotong University
Xi'an, China

Thomas Linner, *Guest Editor*
Department of Systems Design Engineering
Keio University
Tokyo 108-8345, Japan

Yun-Hui Liu, *Guest Editor*
Department of Mechanical and Automation Engineering
The Chinese University of Hong Kong
Hong Kong

Atsushi Yamashita, *Guest Editor*
Department of Precision Engineering
The University of Tokyo
Tokyo 113-8656, Japan

Li Man Yang, *Guest Editor*
School of Automatic Science and Electronics Engineering
Beihang University
Beijing, China

Appendix
Related Work

[A1] C. Yuan, S. Li, and H. Cai, "Vision-based excavator detection and tracking using hybrid kinematic shapes and key nodes," *J. Comput. Civil Eng.*, vol. 31, no. 1, 2017, Art. no. 04016038, doi: 10.1061/(ASCE)CP.1943-5487.0000602.

[A2] C. J. Liang *et al.*, "A vision-based marker-less pose estimation system for articulated construction robots," *Automat. Construction*, vol. 104, pp. 80–94, 2019.

[A3] G. Li and X. Ding, "Sequence optimization of loading/unloading and its automatic generation technique for smart crane," *Chin. J. Mech. Eng.*, vol. 56, no. 18, pp. 254–264, 2020.

[A4] A. Bouton, C. Grand, and F. Benamar, "Design and control of a compliant wheel-on-leg rover which conforms to uneven terrain," *IEEE/ASME Trans. Mechatronics*, vol. 25, no. 5, pp. 2354–2363, Oct. 2020, doi: 10.1109/TMECH.2020.2973752.

[A5] H. S. Yoo and Y. S. Kim, "Development of a 3D local terrain modeling system of intelligent excavation robot," *KSCE J. Civil Eng.*, vol. 21, no. 3, pp. 565–578, 2016.

[A6] Y. Lei *et al.*, "Opportunities and challenges of machinery intelligent fault diagnosis in big data era," *J. Mech. Eng.*, vol. 54, no. 5, pp. 94–04, 2018.

[A7] I. M. Chen and M. Yim, "Modular robots," in *Springer Handbook of Robotics*. New York City: Springer Int. Publ., 2016, pp. 531–542, doi: 10.1007/978-3-319-32552-1_22.

[A8] K. Osuka and S. Yuta, "Special issue on infrastructure maintenance and inspection robotics," *J. Robot. Mechatronics*, vol. 31, no. 6, pp. 743–743, 2019.

[A9] D. Lattanzi and G. Miller, "Review of robotic infrastructure inspection systems," *J. Infrastructure Syst.*, vol. 23, no. 3, 2017, Art no. 04017004.

[A10] A. Habib, M. L. Hung, and G. Nenad, "Review of nondestructive civil infrastructure evaluation for bridges: State-of-the-art robotic platforms, sensors and algorithms," *Sensors*, vol. 20, no. 14, 2020, Art. no. 3954.

[A11] J. M. Mirats Tur and W. Garthwaite, "Robotic devices for water main in-pipe inspection: A survey," *J. Field Robot.*, vol. 27, no. 4, pp. 491–508, 2020.

[A12] S. Agnisarman, S. Lopes, K. C. Madathil, K. Piratla, and A. Gramopadhye, "A survey of automation-enabled human-in-the-loop systems for infrastructure visual inspection," *Autom. Construction*, vol. 97, pp. 52–76, 2019.

[A13] B. F. Spencer, Jr., V. Hoskere, and Y. Narazaki, "Advances in computer vision-based civil infrastructure inspection and monitoring," *Engineering*, vol. 5, no. 2, pp. 199–222, 2019.

[A14] "Prozessmodellierung und –simulation - IAW. (n.d.)," Oct. 1, 2021. [Online]. Available: https://www.iaw-aachen.de/index.php/de/Prozessmodellierung-und-simulation.html

[A15] T. Bock and T. Linner, *Robot-Oriented Design: Design and Management Tools for the Deployment of Automation and Robotics in Construction*. Cambridge, U.K.: Cambridge Univ. Press, 2015, doi: 10.1017/CBO9781139924146.

[A16] Y. Jun, L. Kasahara, H. Fujii, A. Yamashita, and H. Asama, "Weakly supervised acoustic defect detection in concrete structures using clustering-based augmentation," *IEEE /ASME Trans. Mechatronics*, early access, May 4, 2021, doi: 10.1109/TMECH.2021.3077496.

[A17] P. Y. Chun and S. Hayashi, "Development of a concrete floating and delamination detection system using infrared thermography," *IEEE /ASME Trans. Mechatronics*, early access, Sep. 10, 2021, doi: 10.1109/TMECH.2021.3106867.

[A18] M. Ilyas, S. N. M. Khaw, Y. Jin, X. Zhao, and C. C. Cheah, "Robot-Assisted object detection for construction automation: Data and information-driven approach," *IEEE /ASME Trans. Mechatronics*, early access, Jul. 27, 2021, doi: 10.1109/TMECH.2021.3100306.

[A19] M. Kamezaki, H. Iwata, and S. Sugano, "Basic input-output gain tuning system based on control input histogram leveling for human-operated machines," *IEEE /ASME Trans. Mechatronics*, early access, Jul. 7, 2021, doi: 10.1109/TMECH.2021.3095059.

[A20] R. Fan and Y. Li, "An adaptive fuzzy trajectory tracking control via improved cerebellar model articulation controller for electro-hydraulic shovel," *IEEE /ASME Trans. Mechatronics*, early access, Jul. 2, 2021, doi: 10.1109/TMECH.2021.3094284.

[A21] T. Takeyama, H. O-Tani, S. Oishi, M. Hori, and A. Iizuka, "Automatic construction of three-dimensional ground model by data processing," *IEEE/ASME Trans. Mechatronics*, early access, Aug. 31, 2021, doi: 10.1109/TMECH.2021.3105062.

Chien Chern Cheah was born in Singapore. He received the B.Eng. degree from the National University of Singapore, Singapore, in 1990, and the M.Eng. and Ph.D. degrees from Nanyang Technological University, Singapore, in 1993 and 1996, respectively, all in electrical engineering.

From 1990 to 1991, he was a Design Engineer with Chartered Electronics Industries, Singapore. He was a Research Fellow with the Department of Robotics, Ritsumeikan University, Japan, from 1996 to 1998. He is currently an Associate Professor with Nanyang Technological University.

Dr. Cheah was an Associate Editor for *Automatica*. He was an Associate Editor for the IEEE TRANSACTIONS ON ROBOTICS from 2010 to 2013, Programme Co-Chair for IEEE International Conference on Robotics and Automation 2017, Award Chair for IEEE/RSJ International Conference on Intelligent Robots and Systems 2019.

Thomas Bock received a multidisciplinary educational background in architectural, civil, and mechanical engineering. He worked in Iran, Germany, and Spain where he designed modular building systems and supervised its prefabrication and on-site construction. He was involved in road robotics, tunnel boring automation, robotic excavators, drone inspection of bridges, affordable social housing for Singapore, rapid high-rise construction for China, first façade robot for Hong Kong, various laboratories for construction automation and robotics, and assisted living in Italy, Japan, Canada, China, Russia, U.K., Netherlands, Spain, France, and Scandinavia. He is the Co-Founder and Director of the International Association for Automation and Robotics in Construction, and an advisor to the French and Singapore Ministries for construction robotization and industrialization. He had authored or coauthored more than 500 publications, the book series Construction Robotics Handbooks (Cambridge University Press), and holds various honorary professorships, doctorship, fellowship, and visiting and special assigned professorships

Prof. Bock is a Member of the Russian Academy of Sciences for Construction and the Russian Academy of Sciences. He is an Editor of several top journals such as *Automation in Construction* and *Innovation in Construction*.

Jianfu Cao received the bachelor's degree in computer science and the Ph.D. degree in systems engineering from Xi'an Jiaotong University, Xi'an, China, in 1983 and 1996, respectively.

He is currently the Director of the Institute of Automatic Control, Xi 'an Jiaotong University, the Vice President and Secretary General of Shaanxi Automation Association, the Director of Chinese Association of Automation, and the Chairman of Architectural Robot Committee of Chinese Association of Automation. He has also been an Engineer with Beijing Machine Tool Research Institute, Beijing, China, of a large research institute. His research interests include robot control, complex system control and diagnosis, intelligent manufacturing, etc.

Dr. Cao has been selected as the second level of "333" High-Level Talent Project of Jiangsu Province. He presided over more than 40 national and provincial projects such as "75" Science and Technology Research Key, 863, National Natural Science Foundation of China, and key research and development programs. He was the recipient of five provincial and ministerial science and technology awards, including one National Science and Technology Progress Second Prize (ranked 2nd).

Thomas Linner has a multidisciplinary educational background in architectural, civil, and mechanical engineering. He is currently a Senior Scientist and Lecturer in Building Realisation and Robotics, Technical University of Munich, Munich, Germany, and a Guest Associate Professor with the Department of System Design Engineering, Keio University, Tokyo, Japan. He has conducted and supervised several major multipartner research projects, with a focus on the development and deployment of advanced construction and building technology. He is the Founder and Managing Director of CREDO Robotics GmbH, Germany. He holds several patents.

Dr. Linner was the Recipient of several awards and grants, including a Japanese Center of Excellence Grant, the CEN-CENELEC Standards + Innovation Award 2019. He is currently the Convener of WG2/ ISO TC 314, and the Vice President of the International Association for Automation and Robotics in Construction (IAARC). In January 2021, he was appointed by DIN to its Presidial Committee. He is the Scientific Director and Project Manager of a major university–industry collaborative project funded by the European Commission. He is a regular Evaluator for projects in national and international funding schemes, a reviewer for several internationalconferences and journals, an Editor of proceedings and journals, and holds several board of director memberships.

Yun-Hui Liu (Fellow, IEEE) received the Ph.D. degree in applied mathematics and information physics from the University of Tokyo, Tokyo, Japan.

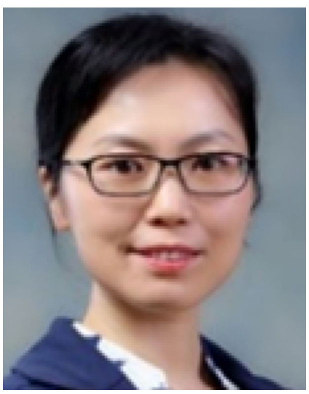
After working at the Electrotechnical Laboratory of Japan as a Research Scientist, he joined The Chinese University of Hong Kong (CUHK), Hong Kong, in 1995 and is currently a Choh-Ming Li Professor of Mechanical and Automation Engineering and the Director of the T Stone Robotics Institute, CUHK. He is also the Director/CEO of Hong Kong Centre for Logistics Robotics, Hong Kong, sponsored by the InnoHK programme of the HKSAR government. He is an Adjunct Professor with the State Key Lab of Robotics Technology and System, Harbin Institute of Technology, Harbin, China. He has authored or coauthored more than 500 papers in refereed journals and refereed conference proceedings. His research interests include visual servoing, logistics robotics, medical robotics, multifingered grasping, mobile robots, and machine intelligence.

Dr. Liu was the recipient of numerous research awards from international journals and international conferences in robotics and automation and government agencies. He was listed in the Highly Cited Authors (Engineering) by Thomson Reuters in 2013. He was the Editor-in-Chief of *Robotics and Biomimetics*, and was an Associate Editor for the IEEE TRANSACTION ON ROBOTICS AND AUTOMATION and the General Chair of the 2006 IEEE/RSJ International Conference on Intelligent Robots and Systems.

Atsushi Yamashita (Senior Member, IEEE) received the B.E., M.E., and Ph.D. degrees in robotics from The University of Tokyo, Japan, in 1996, 1998, and 2001, respectively.

He is currently an Associate Professor with The University of Tokyo, Tokyo, Japan. He was an Assistant Professor with Shizuoka University, Japan, from 2001 to 2008. From 2006 to 2007, he was a Visiting Associate with the California Institute of Technology, USA. From 2008 to 2011, he was an Associate Professor with Shizuoka University. He authored or coauthored more than 400 papers in international journals and conferences. His research interests include construction robotics, robot vision, and intelligent robot system.

Dr. Yamshita was the recipient of the Best Paper Award from the *Journal of Robotics and Mechatronics* in 2018 and the Best Paper Awards from AISM2010, ICAM2015, SII2020, ICNR2020, and so on.



Liman Yang received the M.S. degree in mechanical engineering from Xi'an Jiaotong University, Xi'an, China, in 2001 and Ph.D. degree in mechatronics from Beihang University, Beijing, China, in 2005.

She is currently an Associate Professor with the School of Automatic Science and Electronics Engineering, Beihang University. She has conducted several national key research projects, with a focus on the intelligent control and health management of large mechatronic equipment and construction machinery. Her research interests include networked control systems, nonlinear dynamic modeling and control of mechatronic systems, mobile robots and vehicles, fault prediction, and health management.

Dr. Yang was the recipient of several awards, including the China Machinery Industry Science and Technology Awards. She is a regular Evaluator for projects in national and industry funding schemes, a Reviewer for several international conferences and journals.