Proceedings of the 37th International Symposium on Automation and Robotics in Construction (ISARC 2020)

From Demonstration to Practical Use
- To New Stage of Construction Robot -

Kitakyushu, Japan, October 27-28, 2020

37th ISARC 2020 Online

International Association for Automation and Robotics in Construction

I.A.A.R.C.

Knowledge and Competence

Kazuyoshi Tateyama
Ritsumeikan University
Japan

Kazuo Ishii
Kyushu Institute of Technology
Japan

Fumihiro Inoue
Shonan Institute of Technology
Japan

ISBN 978-952-94-3634-7

1. Edition 2020

Cover design: Masaharu Moteki

Preface

The 1st International Symposium on Automation and Construction (ISARC) was held at Carnegie Mellon University in Pittsburgh, Pennsylvania, USA in 1984. Since then, ISARC has been held all over the world every year to exchange information about the development and practical use of construction robot technology among industry experts, academic researchers and individuals with novel ideas for all fields of construction, civil and building engineering, machine automation, robotics applications to construction, information technologies, planning, logistics, etc.

ISARC has been held in Japan four times so far, but it has not been held here since 2006, because the momentum for the development of construction robots declined rapidly with the economic downturn around 2000. We were very pleased to learn that we would be able to hold the 37th ISARC in Japan in 2020 after 14 years thanks to the recent increase of momentum in the development of construction robots.

For the symposium, we had planned and prepared to organize not only research presentations, but also key note lectures, technical exhibitions and technical visits related to construction robots in use on the island of Kyushu, in the western part of Japan. Last December, we started a call for papers, and more than 390 abstracts were received from 33 countries.

Unfortunately, the infectious disease caused by COVID-19, which started at the end of last year, quickly spread throughout the world, and many people are still suffering from its effects. We would like to express our heartfelt sympathy to all the people who are in a severe situation, including those who have lost loved ones and/or have been infected by the disease.

There is still no clear end in sight to COVID-19. For this reason, in May of this year, we decided to hold the symposium online and immediately started the preparations for an online symposium. However, we had neither the experience nor the know-how to organize an online international symposium. Therefore, our original plan was not necessarily a very productive one. Under these circumstances, we received tremendous support from the IAARC Board members and were able to hold the online symposium successfully. We would like to extend our sincere gratitude to them for their kindness and great cooperation.

Although the number of submitted papers decreased, due to changes related to an online symposium, we still received 221 full papers from 23 countries. We believe that this symposium was very fruitful in terms of cross-national technical exchange among all the participants.

Finally, I would like to express our deepest gratitude to the members of the Japanese local committee for all the work they did with us in planning and preparing for this symposium. I believe that the efforts of all the people involved in this symposium will greatly contribute to the further evolution of construction robots.

Kazuyoshi Tateyama
Chair, 37th ISARC
Professor, Ritsumeikan University, Japan

Introduction

This publication is the Proceedings of the 37th International Symposium on Automation and Robotics in Construction (ISARC). The symposium was held online during 27-28 October 2020. The Proceedings include an illustrated review of the program, the names of organizations and persons who contributed to the technical program, and the 221 technical papers from 23 countries authored for this international meeting.

The manuscripts were presented during 57 sessions on 3 tracks, among them: automation and robotics, building information modeling (BIM), inspection and monitoring, artificial intelligence and machine learning, construction management, safety and health, data sensing and analysis, mixed Realities (AR/VR), control technology, education, environmental sensing and modeling, human sensing and monitoring, IT supported system, database, big data, lean, logistics, prefabrication, modularization, leaning/AI/recognition, human-computer interaction, measurement, modeling and management, new application field of construction robots and machines, risk management, robot and interface design, and robot construction.

Please note: All ISARC proceedings since 1984 are available at no cost at http://www.iaarc.org.

We are very grateful for the support of so many. Thank you!

Prof. Kazuyoshi Tateyama, Ritsumeikan University, Japan (Chair)
Prof. Kazuo Ishii, Kyushu Institute of Technology, Japan (Co-Chair)
Prof. Fumihiro Inoue, Shonan Institute of Technology, Japan (Co-Chair)

Acknowledgements

Symposium host:	The International Association for Automation and Robotics in Construction
	Japanese Council for Construction Robot Research
Symposium sponsors:	Council for Construction Robot Research
	The International Association for Automation and Robotics in Construction
Symposium co-sponsors:	Advanced Construction Technology Center
	Architectural Institute of Japan
	Japan Robot Association
	Japan Construction Machinery and Construction Association
	Japan Society of Civil Engineers
	City of Kitakyushu
	The Robotics Society of Japan
Symposium cooperation:	The Institute of Electrical Engineers of Japan
	Japan Association of Surveyors
	Japan Association for the Unmanned Construction
	Japan Federation of Construction Contractors
	The Japanese Geotechnical Society
	The Japan Society of Mechanical Engineers
	The Japan Society for Precision Engineering
	Kitakyushu Convention & Visitors Association
	The Society of Instrument and Control Engineers
	Sabo & Landslide Technical Center
	New Unmanned Construction Technology Research Association
	Ritsumeikan University
	The Kajima Foundation
	Rent All Scholarship Foundation
Symposium support:	Ministry of Land, Infrastructure, Transport and Tourism

Local Organizing Committee

Chair	Kazuyoshi Tateyama, Ritsumeikan University, Japan
Co-Chair	Fumihiro Inoue, Shonan Institute of Technology, Japan
Co-Chair	Kazuo Ishii, Kyushu Institute of Technology, Japan

Program committee

Chair	Hisashi Osumi, Chuo University, Japan
Co-Chair	Kazuo Kikawada, Hazama Ando Corporation, Japan
Co-Chair	Fumihiro Inoue, Shonan Institute of Technology, Japan
Co-Chair	Mitsuo Kamesaki, Waseda University, Japan

Award committee

Chair	Miho Makatayama, Building Research Institute, Japan

Publication committee

Chair	Masamitsu Kurisu, Osaka University, Japan

Web-management

Chair	Takaaki Yokoyama, Ritsumeikan University, Japan

International relations

Chair	Hiroshi Furuya, Obayashi Corporation, Japan

Finance

Chair	Hiroki Murakami, IHI Corporation, Japan

Secretary-general

Masaharu Moteki, Advanced Construction Technology Center, Japan

Technical Committee

Tatsuo Arai	The Univ. of Electro-Communications
Mantha Bharadwaj	New York Univ. - Abu Dhabi
Thomas Bock	Technical University Munich
Frederic Bosche	University of Edinburgh
Ioannis Brilakis	University of Cambridge
Alessandro Carbonari	Polytechnic University of Marche
Daniel Castro	Georgia Institute of Technology
Soungho Chae	Kajima Corporation
Hung-Ming Chen	Ntl Taiwan Univ. Science & Tech.
Po-Han Chen	Ntl Taiwan University
Yong Cho	Georgia Institute of Technology
Satoru Doi	Obayashi Corporation
Chen Feng	New York University
Yutaro Fukase	Shimizu Corporation
Hiromitsu Fujii	Chiba Institute of Technology
Hiroshi Furuya	Obayashi Corporation
Borja Garcia de Soto	New York University - Abu Dhabi
Jozef Gasparik	Slovak University of Technology
Quang Ha	University of Technology, Sydney
Daniel Hall	ETH Zurich
Kouji Hamada	Obayashi Corporation
Amin Hammad	Concordia University
Takeshi Hashimoto	Public Works Research Institute
Shigeki Hiraoka	Topcon Corporation
Daehie Hong	Korea University Seoul
Koji Ihara	Asunaro Aoki Construction Co., Ltd.
Ryusei Ikeda	East Nippon Expressway Co., Ltd.
Fumihiro Inoue	Shonan Institute of Technology
Genya Ishigami	Keio University
Kazuo Ishii	Kyushu Institute of Technology
Fumio Itoh	Japan Construction Machinery and Construction Association
Yonghoon Ji	Japan Advanced Inst. Science & Tech.
Vineet Kamat	The University of Michigan
Mitsuhiro Kamezaki	Waseda University
Kazuito Kamiyama	Takenaka Corporation
Kazuya Kikawada	Hazama Ando Corporation
Huoungkwan Kim	Yonsei University
Shigeo Kitahara	Kumagai Gumi Co., Ltd.
Taizo Kobayashi	Ritsumeikan University
Markus König	University of Bochum
Masamitsu Kurisu	Osaka University
Soonwook Kwon	Sungkyunkwan University
Junbok Lee	Kyung Hee University
Nan Li	Tsinghua University
Miho Makatayama	Building Research Institute
Leonardo Messi	Polytechnic Univ. of Marche
Naoki Mori	Taisei Corporation
Masaharu Moteki	Advanced Construction Technology Center
Hiroki Murakami	IHI Corporation
Keiji Nagatani	The University of Tokyo
Satoshi Nakamura	Tokyu Construction
Takahiro Nakamura	Kajima Corporation
Tadashi Narise	Maeda Corporation
Yasutoshi Nomura	Ritsumeikan University
Ken Ooi	Komatsu Ltd.
Makoto Oshio	Kajima Corporation
Hisashi Osumi	Chuo University
Benny Raphael	I.I.T. Madras
Saiedeh Razavi	McMaster University
Kazuyuki Sano	Taisei Corporation
Anoop Sattineni	Auburn University
Isaac Shabtai	Israel Institute of Technology
Yasuyuki Shingu	Shimizu Corporation
Shinya Suzuki	Toda Corporation
Piotr Szynkarczyk	Industrial Research Institute for Autom. & Measurement
Hiroki Takabayashi	aT ROBOTICS Inc.
Manabu Takeishi	Hazama Ando Corporation
Toshinari Tanaka	Port & Airport Research Inst.
Jochen Teizer	University of Bochum
Yelda Turkan	Oregon State University
Takao Ueno	Tokyu Construction
Kazunori Umeda	Chuo University
Tomohiro Umetani	Konan University
Enrique Valero	University of Edinburgh
Frans van Gassel	Eindhoven Univ. of Technology
Koshy Varghese	I.I.T. Madras
Józef Wrona	Wajskova Technical Academia
Hiroshi Yamamoto	Komatsu Ltd.
Shinya Yamamoto	Shimizu Corporation
Takaaki Yokoyama	Ritsumeikan University
Zhenhua Zhu	Wisconsin University

Program Schedule

JST*	Tuesday October 27	Wednesday October 28
08:00 – 13:00	Opening Ceremony *Tucker-Hasegawa 2020 Award Keynote Lecture* Academic Presentations	Academic Presentations
14:00 – 15:00	Keynote2	Keynote3
15:00 – 19:00	Academic Presentations	Academic Presentations Award and Closing Ceremony
20:00 – 23:00	Academic Presentations	

*Japan Standard Time

Keynote

Tucker-Hasegawa 2020 Award Keynote Lecture

Hyoungkwan KIM

Professor at Yonsei University, Korea

Smart Safety Assurance for Temporary Structures

Temporary structures on construction sites has been the major cause of worker fatalities. According to a Korean statistics report, about 300 people are losing precious lives each year due to accidents involving temporary structures. A new research program was launched this year to develop a smart safety assurance system that recognizes, evaluates, and predicts accident risks that may occur during the installation, dismantling, and operation of temporary structures. It is a part of the smart construction initiative sponsored by the Korean Ministry of Land, Infrastructure, and Transport, and the Korea Agency for Infrastructure Technology Advancement. The program was designed for developing technologies such as deep learning-based hazard identification, augmented reality-based risk warning, and smart mobility for intelligent sensing of construction sites, with a total budget of ₩12.5 billion ($10.5 million) over six years. The program has a clear goal of reducing the number of accidents related to temporary structures by more than 25% through the creation of a new construction culture, safety-related policies, and safety-related industries.

Speaker profile:

Hyoungkwan KIM, Ph.D. is a Professor of the School of Civil and Environmental Engineering at Yonsei University, Korea. His areas of research include construction automation, infrastructure adaptation to climate change, and project finance. He is the principal investigator of a $10.5 million research program titled “Smart Safety Assurance for Temporary Structures,” which is a part of smart construction initiative sponsored by the Korean Ministry of Land, Infrastructure, and Transport, and the Korea Agency for Infrastructure Technology and Advancement. He serves as Vice- President for the International Association for Automation and Robotics in Construction (IAARC), and Associate Editor for Journal of Computing in Civil Engineering, American Society of Civil Engineers (ASCE). He also served as Secretary General for Association for Engineering Education in Southeast Asia and the Pacific (AEESEAP). He has received six excellent teaching awards and an excellent research award from Yonsei University. More information on Prof. Kim can be found at: http://aim.yonsei.ac.kr.

Keynote 2

Naoki SATO

Director of the Space Exploration System Technology Unit, The Japan Aerospace Exploration Agency (JAXA), JAXA Space Exploration Center (JSEC), Japan

International Space Exploration and Japanese Lunar Activities

JAXA is engaged in international collaborations to tackle the challenge of human and robotic exploration missions in and beyond low-Earth orbit (LEO). The current focus is exploration missions to the Moon and Mars, targeting future human activities. His presentation introduced Japan's current exploration activities and JAXA's future plans and studies beyond the Earth orbit with the context of international coordination. Especially for the lunar surface activities, the concept study of the lunar base construction, which JAXA had conducted with a group of construction-related companies across Japan, was introduced along with the technological development.

Speaker profile:

Naoki SATO graduated from the Aeronautics Engineering Department, Kyusyu University in 1986, and gained a master degree of applied engineering of Kyusyu University in 1988. In the same year, he entered the National Space Development Agency of Japan (predecessor of JAXA). From 1990 he had been involved in the International Space Station program for about 16 years. Afterwards, he has been working for the international space exploration program formulation. Since April 2018 he is the current ISECG chair and since July 2018 he was assigned as the Director of the Space Exploration System Technology Unit of JAXA Space Exploration Center (JSEC).

Keynote 3

Yasushi NITTA

Director for Construction Equipment and Safety Planning Office, Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan

Initiatives for Robot Introduction in Japanese Public Works

The Japanese society faces various social issues such as frequent occurrences of earthquakes, eruption of volcanoes, floods, landslides, etc., resulting in the deterioration of the infrastructure. Japan also sees a reduction of the working population in the construction industry. In his speech, he introduced initiatives for the social implementation of robots and information and communication technologies in the Japanese construction industry, including the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Speaker profile:

After graduating from University of Tsukuba in 1994, Dr. Yasushi NITTA joined the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). There he is widely engaged in policy planning, public works and R&D in the various departments, such as MLIT Headquarters, Regional Development Bureau, National Road Office, National Research Institutes (PWRI, NILIM), Advanced Construction Technology Center (ACTEC). He is especially responsible for the planning and operation of on-site verification projects to promote the introduction of robots to the infrastructure department, development/deployment/budgeting/operation of disaster

countermeasure machines, and nationwide deployment of machine construction (i-Construction) using 3D data. Dr. NITTA is also engaged in establishing technical standards for the purpose, demonstrating ultra-long-distance unmanned construction technology, and flood control as an international emergency relief team.

Video list

Construction robots in Japan

1. **Sea Experiment on Tele-operation System of Underwater Excavator**
   National Institute of Maritime, Port and Aviation Technology,
   Port and Airport Research Institute,
   Infrastructure Digital Transformation Engineering Department
2. **Development of Heavy Carrier Robot for Shallow Water Area**
   New Unmanned Construction Technology Research Association
3. **Tunnel RemOS-WL**
   Kanamoto Co., Ltd.
4. **kana Robo – Robo-Construction System –**
   Kanamoto Co., Ltd.
5. **kana Robo – Robo-Construction System 2 –**
   Kanamoto Co., Ltd.
6. **ROBO CONSTRUCTION – DokaBOri Training –**
   Fujiken Co,Ltd.
7. **"A4CSEL" at the Seisho Test and Practice Field**
   KAJIMA CORPORATION
8. **Pursuing "Zero Ground Subsidence" in Shield Tunneling**
   TAC Corporation
9. **Automatic Dam Concrete Placing System**
   SHIMIZU CORPORATION
10. **Automatic Tunnel Lining Concrete Placing System**
    SHIMIZU CORPORATION
11. **A robot that assists in plotting**
    SHIMIZU CORPORATION
12. **Development of IT construction system by Robot**
    Public Works Research Institute
13. **Demonstration of autonomous excavation, loading and unmanned bulldozer. (CEATEC2018)**
    Komatsu Ltd., Office of CTO
14. **Smart Construction Concept, Future image. (CEATEC2018)**
    Komatsu Ltd., Office of CTO
15. **BE A HERO, Future image**
    Komatsu Ltd., Office of CTO
16. **DEEP CRAWLER - Crawler type ROV**
    WAKACHIKU CONSTRUCTION Co., Ltd.
17. **What is dredging? - A job that protects the safety of the sea**
    WAKACHIKU CONSTRUCTION Co., Ltd.
18. **Robotic rubble-mound mechanized construction system**
    PENTA-OCEAN CONSTRUCTION CO., LTD.
19. **Rotation Control Device for Lifting Cargo**
    WAKACHIKU CONSTRUCTION Co., Ltd.
20. **Automatic operation system of the construction machine (Vibrating roller・Bulldozer)**
    HAZAMA ANDO CORPORATION

Table of Contents