Guest Editorial Special Section on Robotics for Fourth Industrial Revolution

THE idea of the fourth industrial revolution, which was coined from that of "Industry 4.0" mainly for the manufacturing field, was first introduced with great expectations to have substantial impact on all industrial areas in the future and bring massive changes in all our lives at the world economy forum in Davos 2016. The concept of the fourth industrial revolution has drawn attention throughout the world and many efforts to define the concept in diverse fields have continued. Generally, the concept can be summarized as the technology convergence through hyper-intelligence and hyper-connectivity.

The core technologies providing the thrust of the fourth industrial revolution, especially in the industrial informatics field, are Internet of Things, robotics, virtual reality, and artificial intelligence. As one of the most critical characteristics of the fourth industrial revolution technology is that the boundary between cyber space and physical space becomes unclear, innovations in industry and business initiate through the fusion of these two spaces. It is the *robotic system* that plays the key role as *a physical medium* linking cyber and physical spaces and even changing the physical space through direct interactions. In this sense, robotic system should be recognized as a crucial platform in performing tasks in the cyber-physical space.

Acknowledging the fact that much latest advancement with core robotic technologies are not being recognized widely, while they have been contributing to the initiation of the fourth industrial revolution, we Guest Editors have come to a fruition to introduce some of the noticeable work through this special section.

A total of 33 papers were submitted, of which eight outstanding papers were selected to be published. The paper topic can be categorized into two fields: autonomous system and control and perception and human–robot interaction (HRI).

1) Autonomous Robot System and Control: Four articles, selected for the autonomous system and control field, present the work related to autonomous unmanned vehicles within various environments and the software architecture that controls a platoon of vehicles.

The first paper in this area is "Designing Dynamic and Collaborative Automation and Robotics Software Systems" by Salcic *et al*. This paper elaborates upon those challenges and proposes using an approach called service-oriented SystemJ, based on the system-level programming language SystemJ enhanced with service-oriented features.

In the paper "Nonlinear High-Gain Observer-Based Diagnosis and Compensation for Actuator and Sensor Faults in a Quadrotor Unmanned Aerial Vehicle" by Ma *et al*., the diagnosis and compensation method without adding sensors or actuators is proposed for sensor and actuator faults in a quadrotor unmanned aerial vehicle.

In multiple vehicle coordination, the formation control is an important issue, and the leader–follower formation is one of the popular methods. The paper entitled "Leader–Follower Formation Control of USVs with Prescribed Performance and Collision Avoidance" by He *et al*., proposes leader–follower formation control that can consider the prescribed performance and collision avoidance in the presence of uncertainties and disturbances.

In the paper, "Adaptive Motion Planning Based on Vehicle Characteristics and Regulations for Off-Road UGVs" by Ji *et al*., the authors proposed a random sampling-based motion planning algorithm of off-road UGVs that finds a smooth path satisfying roll-pitch angle constraints with careful expansion of random trees in OctoMap.

2) Perception and HRI: In the field of perception and HRI, the studies regarding human–machine interaction improvement using various modalities such as visual, auditory, tactile, and EMG signals were presented.

In the paper "Restoring Aspect Ratio Distortion of Natural Images With Convolutional Neural Network" by Sakura *et al*., the authors developed a robust method to restore aspect ratio distorted images using the convolutional neural network.

In the paper entitled "Driving Assistant Companion With Voice Interface Using Long Short-Term Memory Networks" by Park *et al*., the authors propose a driving assistant system that fuses range sensor values from an autonomous vehicle during driving (in simulation) and trains a long-short term memory network to predict driving conditions and finally assist a user via voice feedback. The authors conducted a user study with 16 participants, with which it was shown that the performance and reliability of the user's driving training can be enhanced.

In the paper "Development of Vibrotactile Pedestal With Multiple Actuators and Application of Haptic Illusions for Information Delivery" by Yang *et al*., the authors developed a vibrotactile pedestal with multiple actuators, and applied to smartphones to create a sense of information according to location and direction.

In the last paper entitled "Programming by Demonstration Using the Tele-Impedance Control Scheme: Verification

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by a sEMG-Controlled Ball-Trapping Robot" by Park *et al*., the authors propose a path and impedance planning method for impedance control in a robot based on programming by demonstration through telemanipulation using a surface electromyogram.

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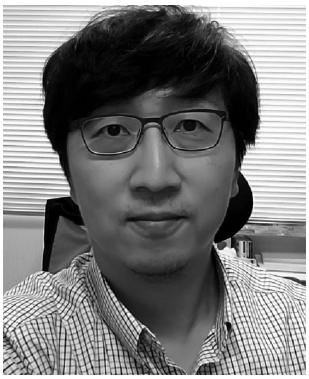

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