Guest Editorial: Special Issue on Artificial Intelligence for Robotics

ARTIFICIAL intelligence (AI) technologies, covering cognition, analysis, inference, and decision-making, enable robots to act smartly and greatly enhance robots' capabilities to assist and support humans. As a primary carrier of AI technologies, robotics is one of the applications for AI to demonstrate its strong ability. Augmenting robots with AI technologies for the engineering systems, robots are expected to have more pervasive applications in industry, agriculture, logistics, medicine, and to name but a few. This special issue will be dedicated to AI for robotics, including AI to support human–robot interaction, AI for multirobot systems, AI learning algorithms in robotics, ethics of AI in the context of robotics, and applications of AI-enabled robots. The special issue will publish original papers of innovative ideas and concepts, discoveries and improvements, and novel applications to the field of AI for robotics. Topics covered in this special issue include, but are not limited to AI for multirobot systems, AI in autonomous systems, AI in cognitive robotics, AI in human–robot interaction, AI-enabled robots to assist health professionals as in the case of COVID-19, applications of AI-enabled robots in industry, agriculture, logistics, medicine, augmented intelligence in robotics, conversational AI and natural language processing for robotic systems, deep learning systems and methods in robotics, explainable and interpretable AI for robotic system, machine learning methods in robotics, perception, reasoning, and planning in advanced intelligent robot tasks, technical papers on Ethics and social implications of AI in robotics.

This special issue received 17 articles on AI for robotics from different countries, of which seven articles contributed significantly and were accepted for publication in this special issue. The contents of these seven articles are briefly described as follows.

The first paper in the special issue focuses on the graph-based knowledge acquisition method with convolutional networks for distribution network patrol robots. To enrich the knowledge of patrol robots in this complex scenario, Yan *et al.* [item 1) in the Appendix] present the graph-based knowledge acquisition method with convolutional networks for distribution network patrol robots. The proposed algorithm generates the embeddings of entities and relations through aggregating the associated entity in the associated paths instead of only the connected entity. The experimental results verify that the proposed method outperforms the other methods for the real distribution network datasets. The proposed method can be used in field. The patrol robots with the proposed method have the ability to analyze the equipment defects.

The inspection and surveillance in complex industrial sites, such as substations, nuclear power plants, and offshore platforms, play an essential role in diagnosing device status, discovering abnormalities, and preventing potential hazards. Among all kinds of agents, movable patrol robots could travel in unstructured terrains while perceiving, processing, and transferring data with decent accuracy 24 h a day, ensuring that the equipment's vital information is interpreted correctly. To enhance high accuracy, flexibility, and real-time performance, Dong *et al.* [item 2) in the Appendix] propose the vector detection network to detect analog meters' pointers given their images, eliminating the barriers for autonomously reading such meters using intelligent agents like robots. The proposed vector detection network could be used to detect objects of this kind, such as the branch of plants, helping the agriculture robots do accurate trimming.

In the human–robot interaction, modeling and estimating human arm dynamics show great potential for achieving more natural and safer interaction. To enrich the skill and guarantee the accuracy of the manipulation, Su *et al.* [item 3) in the Appendix] propose a novel algorithm using deep learning to explore the potential model between surface electromyography (sEMG) signals of the human arm and interaction force for human–robot interactions. Its features are extracted by adopting the convolutional neural network from the sEMG signals automatically without prior knowledge of the biomechanical model. The performance of the proposed algorithm is demonstrated by using the Myo controller and KUKA LWR4+ robot. This technique could offer an alternative way for predicting the interaction force of human–robot interaction.

Robotics is one important domain of AI applications. Facial emotion recognition plays an important part in human–robot interaction. Although different works have been proposed to complete the task of emotion recognition, conventional methods often require a lot of time and memory resources. Li *et al.* [item 4) in the Appendix] propose an enhanced broad Siamese network algorithm for facial emotion recognition in robotic applications, combining broad learning system with Siamese network and further improving mechanism of similarity metric. The experimental results show that the developed method can achieve a comparable performance to conventional deep learning method, while reducing consumption of computing time and memory resources.

Artificial prosthetic limbs as an alternative to the lost limb are designed to allow amputees to regain motor function. However, limited classification of discrete motion patterns from sEMG

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prevents intuitive motor control. Li *et al.* [item 5) in the Appendix] propose a muscle synergy-based intention decoding and motion planning that can model a broad set of complex upper-limb movements as a combination of motor primitives. A neural network approximation-based controller is designed for the bionic neuro-prosthetic arm to execute the movement. Operational experiments with prosthetic movement control were performed on four healthy participants and an upper-limb amputee participant. Experimental results show the proposed control method could successfully capture human movement intention and effectively control the movement of the prosthesis.

The drastic changes in flight parameters during aerobatics and the high instability of the system make the control of autonomous aerobatics unusually difficult. Chen *et al.* [item 6) in the Appendix] use the proposed deep feature representation network to directly map the experts' demonstration trajectory to a deep representation space spanned by a set of learned subspaces representing the movement patterns with the same statistical data property among demonstration trajectories. Accordingly, the proposed method can perform arbitrary aerobatic maneuvers by observing a limited set of expert demonstrations. The effectiveness of the deep feature representation-based imitation learning method is verified on the real-world flight data. This method is not limited to helicopter autonomous aerobatics, but can also be employed to address similar problems in other areas of robotics.

The human–computer interface (HCI) system is widely implemented in the robotics field. The sEMG-based hand gesture recognition is prevalent in HCI systems. However, the generalization of the recognition model does not perform well. Zou *et al.* [item 7) in the Appendix] propose a multiscale kernel convolutional neural network (MKCNN) model to extract and fuse multiscale features of the multichannel sEMG signals. Based on the proposed MKCNN model, a transfer learning model named TL-MKCNN combines the MKCNN and its siamese network by a custom distribution normalization module and a distribution alignment module to realize domain adaptation. This method provides a valuable framework for improving the generalization of the deep learning model in the sEMG-based hand gesture recognition.

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APPENDIX: RELATED WORK

[1] D. Yan, H. Cao, T. Wang, R. Chen, and S. Xue, "Graph-based knowledge acquisition with convolutional networks for distribution network patrol robots," *IEEE Trans. Artif. Intell.*, doi: 10.1109/TAI.2021.3087116.

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