Guest Editorial Special Issue on Computational Intelligence for Perception and Decision-Making of Autonomous Systems

Due to powerful capabilities in environmental perception, real-time computing, and intelligent decision-making, autonomous systems have demonstrated their great potential to efficiently accomplish a variety of complex tasks that humans cannot. Hence, autonomous systems are able to facilitate the development of almost every walk of life and have attracted increasing attention from both academia and industry. However, given high dimensional, heterogeneous, unstructured, and unpredictable data sampled from different modalities of sensors, autonomous systems with conventional algorithms may fail to acquire the accurate information related to the environment, and make the appropriate decision to complete assigned tasks. Notice that recent advanced computational intelligence algorithms including deep neural networks and evolutionary algorithms have the unique ability to efficiently extract useful information from the multi-source heterogeneous data, and thus have been successfully applied in the fields of computer vision, natural language processing, and so on. Therefore, it is promising to have a thorough and tight integration between computational intelligence and autonomous systems by upgrading advanced and innovative computational intelligence algorithms to ensure high-level environmental perception and decision-making of autonomous systems.

This special issue aims to report the most recent advances in computational intelligence-based technologies and methodologies for improving the perception and decision-making of autonomous systems. As one of the important branches of artificial intelligence, the emerging computational intelligence is promising to enhance the perception ability of autonomous systems by means of semantic segmentation, depth assessment, object detection, environmental 3D structure perception and ego-motion estimation. Besides, the decision-making ability of autonomous systems can also be improved with the usage of multitude computational intelligence methods such as deep learning, reinforcement learning, and evolutionary computation. Given this, the purpose of this special issue is to address challenging bottleneck problems of extending computational intelligence to autonomous systems in practical application scenarios.

In order to realize the aforementioned goals, the guest editors of this special issue of IEEE Transactions on Emerging Topics in Computational Intelligence (TETCI) have comprehensively evaluated the originality, quality, and relevance of all the submitted papers. Through a rigorous and careful review process, seven high-quality papers have been selected for publication. Overall, these papers provide very feasible and interesting approaches from different perspectives of computational intelligence to explore means to improve the perception and decision-making of autonomous systems. Through these selected papers, researchers can intuitively understand the states-of-the-art, challenges, and future directions in applying computational intelligence to autonomous systems. The details of these papers are given below.

In the aspect of environmental perception, three of the selected papers dedicate to developing computational intelligence algorithms to accurately monitor the process state of different types of autonomous systems. Specifically, the paper entitled "Monitoring Social Distancing with Single Image Depth Estimation" by Alessio Mingozzi et al. proposes a deep learning algorithm to realize the single RGB image-based depth estimation, which can perceive the 3D structure of the observed scene and estimate the distance between people. Compared with previous computer vision-based deep estimation, the proposed algorithm does not need to allocate additional depth sensors and can maintain a high-level computational efficiency in the meanwhile. Moreover, by employing a calibrated LiDAR + RGB camera to obtain the indoor and outdoor images, the proposed method is validated to enable sufficiently reliable estimation of the inter-personal distance to monitor social distancing effectively.

To improve the efficiency and accuracy of monitoring the pharmaceutical product quality in drug manufacture, the paper entitled "Pharmaceutical Foreign Particle Detection: An Efficient Method Based on Adaptive Convolution and Multiscale Attention" by Junfei Yi et al. proposes an end-to-end deep learning algorithm to locate and classify foreign particles. By utilizing the pixel-adaptive feature extraction, multiscale attention-based feature fusion, and feature-selective anchor-free detection, the proposed method can efficiently extract fine-grained features of particles and quickly detect foreign particles in liquid pharmaceuticals.

Considering the low efficiency and accuracy of brain decoding based on the Electroencephalography (EEG) channel, the paper entitled "Efficient Brain Decoding Based on Adaptive EEG Channel Selection and Transformation" by Jiaxing Wang et al.

Date of current version 28 November 2022.
Digital Object Identifier 10.1109/TETCI.2022.3219539

proposes an efficient end-to-end brain decoding model named AdaEEGNet, which adaptively selects the input channels to reduce the computational cost, and reduces the over-fitting to improve the classification accuracy. The experimental results show that the proposed method has an effect in improving the efficiency and accuracy of brain decoding, and thus the brain activities can be monitored and identified with less classification error.

While in the aspect of decision-making, the rest of the selected papers contribute to intelligently determining the optimal strategy for autonomous systems on the basis of computational intelligence. The paper entitled "Optimal Actor-Critic Policy with Optimized Training Datasets" by Chayan Banerjee et al. proposes a strategy to optimize the training datasets for the Actor-Critic (AC) algorithm and improve its sampling efficiency. Compared with other contemporary AC algorithms, the proposed method has a higher sampling efficiency, faster convergence speed, and more data-efficiency, and thus has a better performance in controlling autonomous systems.

In the environment of multi-player dynamic games, learning the winning strategies for monopoly helps to optimize the decision-making process for the players. The paper entitled "Decision Making in Monopoly Using a Hybrid Deep Reinforcement Learning Approach" by Trevor Bonjour et al. proposes a hybrid approach that combines deep reinforcement learning with a fixed-policy approach, and develops learning agents using proximal policy optimization (PPO) and double deep Q-learning (DDQN) algorithms. According to experimental results, the agents with the proposed method have a higher win rate than the traditional fixed-policy agents.

To ensure that a mobile robot with dual arms can fulfill an explosive disposal task, the paper entitled "Motion Planning and Cooperative Manipulation for Mobile Robots with Dual Arms" by Fuchun Sun et al. proposes a hybrid control approach, which utilizes a rapidly-exploring random tree-based motion planning to realize dynamic collision avoidance, develops the dual-arm master-slave coordinated mechanism to achieve the trajectory planning, advances the impedance control approach with slippage detection to produce a stable in-hand manipulation, and employs the Faster R-CNN to determine the grasping region for robot manipulation.

Finally, the paper entitled "Multi-Robot Learning Dynamic Obstacle Avoidance in Formation with Information-Directed Exploration" by Junjie Cao et al. proposes an algorithm to generate distributed collision-free velocities for multi-robot, and maintain multi-robot formation in the meanwhile. The decision-making of adaptive formation is trained by distributed reinforcement learning to avoid dynamic obstacles on the top of consensus velocities, and the optimal policy is constructed by the Bayesian Linear Regression based on a neural network.

In summary, this special issue presents seven key papers that propose advanced and novel computational intelligence technologies to substantially improve the environmental perception accuracy and intelligent decision-making ability of autonomous systems. As guest editors, we would like to express our sincere thanks to all the authors who submitted their work to this special issue, and all the reviewers for their great efforts in ensuring the quality of the selected papers. In addition, we would like to express our heartiest gratitude for the great support of the Editor-in-Chief, Prof. Yew-Soon Ong and Editorial Assistant Ms. Chit Lin Su throughout the editing process of this special issue. We hope that all the selected papers can further accelerate the development of autonomous systems in various application fields such as industrial manufacturing, urban transportation, and medical care, to name a few.

YANG TANG, *Guest Editor*
The Key Laboratory of Smart Manufacturing in Energy Chemical Process, Ministry of Education
East China University of Science and Technology
Shanghai, No. 130 Meilong Road, China
tangtany@gmail.com

GARY G. YEN, *Guest Editor*
School of Electrical and Computer Engineering
Oklahoma State University
Stillwater, Oklahoma 74078-5032 USA
gyen@okstate.edu

JÜRGEN KURTHS, *Guest Editor*
Institute of Physics
Humboldt University of Berlin
12489 Berlin, Germany
juergen.kurths@pik-potsdam.de

Yang Tang (Senior Member, IEEE) received the B.S. and Ph.D. degrees in electrical engineering from Donghua University, Shanghai, China, in 2006 and 2010, respectively. From 2008 to 2010, he was a Research Associate with The Hong Kong Polytechnic University, Hong Kong. From 2011 to 2015, he was a Postdoctoral Researcher with the Humboldt University of Berlin, Berlin, Germany, and with the Potsdam Institute for Climate Impact Research, Germany. He is currently a Professor with the East China University of Science and Technology, Shanghai, China. His research interests include distributed estimation/ control/optimization, cyber-physical systems, hybrid dynamical systems, computer vision, and reinforcement learning and their applications. He was the recipient of the Alexander von Humboldt Fellowship and has been the ISI Highly Cited Researchers Award by Clarivate Analytics since 2017. He is a Senior Board Member of Scientific Reports, an Associate Editor for the IEEE TRANSACTIONS ON NEURAL NETWORKS AND LEARNING SYSTEMS, IEEE TRANSACTIONS ON CYBERNETICS, IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS-I: REGULAR PAPERS, IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTATIONAL INTELLIGENCE, IEEE TRANSACTIONS ON COGNITIVE AND DEVELOPMENTAL SYSTEMS, IEEE SYSTEMS JOURNAL, and ENGINEERING APPLICATIONS OF ARTIFICIAL INTELLIGENCE (IFAC Journal). He is the Leading Guest Editor of special issues in IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTATIONAL INTELLIGENCE and IEEE TRANSACTIONS ON COGNITIVE AND DEVELOPMENTAL SYSTEMS.

Gary G. Yen (Fellow, IEEE) received the Ph.D. degree in electrical and computer engineering from the University of Notre Dame, Notre Dame, IN, USA, in 1992. He was with the Structure Control Division, U.S. Air Force Research Laboratory, Albuquerque, NM, USA. In 1997, he joined Oklahoma State University (OSU), Stillwater, OK, USA, where he is currently a Regents Professor with the School of Electrical and Computer Engineering. His research interests include intelligent control, computational intelligence, conditional health monitoring, signal processing, and their industrial/defense applications. Dr. Yen was the recipient of the Andrew P Sage Best Transactions Paper Award from the IEEE Systems, Man and Cybernetics Society in 2011 and the Meritorious Service Award from the IEEE Computational Intelligence Society in 2014. He was the General Chair for the 2003 IEEE International Symposium on Intelligent Control held in Houston, TX, USA, and the 2006 and 2016 IEEE World Congress on Computational Intelligence held in Vancouver, BC, Canada. He was the Vice President for the Technical Activities from 2005 to 2006 and then as the President of the IEEE Computational intelligence Society from 2010 to 2011. He was an Associate Editor for the *IEEE Control Systems Magazine*, IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY, *Automatica*, *Mechatronics*, IEEE TRANSACTIONS ON SYSTEMS, MAN AND CYBERNETICS, PARTS A AND B, and IEEE TRANSACTIONS ON NEURAL NETWORKS. From 2006 to 2009, he was the Founding Editor-in-Chief of the *IEEE Computational Intelligence Magazine*. He is currently an Associate Editor for the IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION, IEEE TRANSACTIONS ON ARTIFICIAL INTELLIGENCE, IEEE TRANSACTIONS ON EMERGING TOPICS ON COMPUTATIONAL INTELLIGENCE, and IEEE TRANSACTIONS ON CYBERNETICS.

Jürgen Kurths received the B.S. degree in mathematics from the University of Rostock, Rostock, Germany, the Ph.D. degree from the Academy of Sciences, German Democratic Republic, Germany, in 1983, and has received 8 Honorary Doctoral degrees. From 1994 to 2008, he was a Full Professor with the University of Potsdam, Potsdam, Germany. Since 2008, he has been a Professor of nonlinear dynamics with the Humboldt University of Berlin, Berlin, Germany and the Chair of the research domain transdisciplinary concepts with the Potsdam Institute for Climate Impact Research, Potsdam, Germany. He has authored more than 680 articles, which are cited more than 50,000 times (H-index: 111). His research interests include synchronization, complex networks, time series analysis, and their applications. Since 2009, he has been the Sixth-Century Chair with the University of Aberdeen, Aberdeen, U.K. He became a Member of the Academia Europaea in 2010, the Macedonian Academy of Sciences and Arts in 2012, and the Royal Society of Edinburgh in 2021. He is a Fellow of the American Physical Society. He was the recipient of the Alexander von Humboldt Research Award from the Council of Scientific and International Research, India, in 2015 the Richardson Award from the European Geophysical Union in 2013 and the Lagrange award in 2022. He is named as an ISI Highly Cited Researcher in physics and engineering by Thomson Reuters. He is the Editor-in-Chief of CHAOS.