Guest Editorial From Intelligent Control to Smart Management of Cyber-Physical-Social Systems: A Celebration of 70th Anniversary of Cybernetics by Norbert Wiener

INSPIRED by the idealism embodied in Russell and Whitehead's "Principia Mathematica," Wiener marched along a different and unique path toward sciences of intelligence and behavior which culminated at "Cybernetics: Or Control and Communication in the Animal and the Machine" 70 years ago. Since then, we have witnessed the birth of Cognitive Science, Artificial Intelligence (AI), Computational Intelligence, and many other new research fields and disciplines, all of which have been catalyzed by Cybernetics. The IEEE Systems, Man, And Cybernetics Society and this TRANSACTIONS ON CYBERNETICS have become the focal point of the broad cybernetics community by promoting the theory, practice, and interdisciplinary aspects of systems science and engineering, human-machine systems, and cybernetics principles. It is a time of celebration and reflection.

Our focus is on the social aspects of engineering systems, in the special issue since according to Andre-Marir Ampere, the original meaning of Cybernetics is the management of state affairs. In recent years, cybernetics has contributed to tremendous advances ranging from intelligent control to smart management of cyber-physical-social systems (CPSS). Human factors are embedded into CPSS as a part of systems instead of placing them outside the systems boundary. Such structures not only represent a new generation of systems that integrate computing and communication capabilities with the dynamics of physical and engineered world but also consist of mental capabilities, social elements, and especially human experiences. It is interesting and challenging to develop novel theories of CPSS due to its modern practical application potential. Further refinement of the CPSS needs the advancement of interdisciplinary theory in both human and computational studies.

The main objective of this special issue is to celebrate the 70th Anniversary of Cybernetics by Wiener, and exhibit recent developments from intelligent control to CPSS, including topics, such as optimal data injection attacks, secure estimation, adaptive intelligent control, descent gradient algorithm, noncooperative game strategy, adaptive q-learning, parallel intelligence, etc. More specifically, this special issue intends to provide an up-to-date overview of recent advances of cognitive architectures and parallel intelligent systems in CPSS theory and extended application in newly evolving topics.

Following a rigorous peer-review process, 15 submissions were accepted. The contents of the special issue are summarized as follows.

Ye *et al.* presented a survey of agent cognitive architectures to summarize the related AI research in the past 20 years. Based on big data and cloud computing, a novel parallel control strategy was proposed for distributed parameter systems by Song *et al.* Through introducing a closed-form switching approach, the problem of optimal data injection attack design for cyber-physical systems was investigated by Wu *et al.* By building the optimal setting module and developing a self-adjusting neural network with an adaptive learning rate, Xie *et al.* proposed a coordinated optimization method for setting the descent gradient of outlet ferrous ion concentration. The data-based optimal output regulation control problem of discrete-time systems was studied by Luo *et al.* A novel I-Ching operator was introduced by Zhang *et al.*, which evolved from ancient Chinese I-Ching philosophy to devised substitution boxes. A systematic way to incorporate the decision maker's preference information into the decomposition-based evolutionary multiobjective optimization scheme was proposed by Li *et al.* By using the green house as en example, an agricultural CPSS was presented by Kang *et al.*, which can serve agricultural production management effectively. Chen *et al.* studied the noncooperative game strategy of nonlinear stochastic cyber financial systems with continuous and discontinuous random fluctuations, and the high profit and financial risk were guaranteed. According to artificial systems, computational experiments, and the parallel execution method, the framework of parallel intelligent systems was introduced by Dong *et al.* Meanwhile, the initial investigation on using the parallel intelligent systems for integrated high-speed train control and dynamic scheduling was also provided.

In order to save communication resources, Cao *et al.* introduced an event-triggered scheme for nonlinear strict-feedback systems, in which the actuator failure was taken into

Digital Object Identifier 10.1109/TCYB.2018.2879213

consideration. For recognizing the faults of the Tennessee-Eastman process, Zou *et al.* devised a novel orthogonal incremental extreme learning machine to address such problems. Due to the fact that the HIV intervention is difficult to realize, Zhang *et al.* proposed a new partition-based random search method and demonstrated its advantages versus the benchmark nested partitions method and network-based metrics. Considering the vulnerability of cyber-physical systems, Wu *et al.* designed a novel sliding mode observer to estimate states, attacks, and unknown inputs. Considering the attacks of a class of frequency constrained sensors and actuators, Huang *et al.* proposed a new attack compensator, which can ensure the stability and a nearly desired system performance of the cyber-physical systems.

Finally, we would like to acknowledge the editorial office and the Editor-in-Chief of IEEE TRANSACTIONS ON CYBERNETICS, Prof. J. Wang for their great support to the special issue. We would also like to thank all of the authors who submitted their high quality papers to this Special Issue. We express our appreciation to all anonymous reviewers who contributed to the success of this special issue.

FEI-YUE WANG
State Key Laboratory for Management and Control of Complex Systems
Chinese Academy of Sciences
Beijing 100190, China
Qingdao Academy of Intelligent Industries
Qingdao 266109, China.
e-mail: feiyue@ieee.org

DIMITAR P. FILEV
Ford Motor Company
Dearborn, MI 48121 USA
e-mail: dfilev@ford.com

WITOLD PEDRYCZ
Department of Electrical and Computer Engineering
University of Alberta
Edmonton, AB T6R 2V4, Canada
e-mail: wpedrycz@ualberta.ca

HONGYI LI
School of Automation
Guangdong University of Technology
Guangzhou 510006, China
College of Engineering
Bohai University
Jinzhou 121013, China
e-mail: lihongyi2009@gmail.com

CHELSEA C. WHITE, III
H. Milton Stewart School of Industrial and Systems Engineering
Georgia Institute of Technology
Atlanta, GA 30332 USA
e-mail: cwhite@isye.gatech.edu

APPENDIX
RELATED WORK

1) P. Ye, T. Wang, and F.-Y. Wang, "A survey of cognitive architectures in the past 20 years," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3280–3290, Dec. 2018, doi: 10.1109/TCYB.2018.2857704.
2) Y. Song *et al.*, "Parallel control of distributed parameter systems," *IEEE Trans.Cybern.*, vol. 48, no. 12, pp. 3291–3301, Dec. 2018, doi: 10.1109/TCYB.2018.2849569.
3) G. Wu, J. Sun, and J. Chen, "Optimal data injection attacks in cyber-physical systems," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3302–3312, Dec. 2018, doi: 10.1109/TCYB.2018.2846365.
4) S. Xie, Y. Xie, T. Huang, W. Gui, and C. Yang, "Coordinated optimization for the descent gradient of technical index in the iron removal process," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3313–3322, Dec. 2018, doi: 10.1109/TCYB.2018.2833805.
5) B.-S. Chen, W.-Y. Chen, C.-T. Young, and Z. Yan, "Noncooperative game strategy in cyber-financial systems with Wiener and poisson random fluctuations: LMIs-constrained MOEA approach," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3323–3336, Dec. 2018, doi: 10.1109/TCYB.2018.2869018.
6) B. Luo, Y. Yang, and D. Liu, "Adaptive q-learning for data-based optimal output regulation with experience replay," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3337–3348, Dec. 2018, doi: 10.1109/TCYB.2018.2821369.
7) T. Zhang, C. L. P. Chen, L. Chen, X. Xu, and B. Hu, "Design of highly nonlinear substitution boxes based on I-Ching operators," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3349–3358, Dec. 2018, doi: 10.1109/TCYB.2018.2846186.
8) K. Li, R. Chen, G. Min, and X. Yao, "Integration of preferences in decomposition multiobjective optimization," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3359–3370, Dec. 2018, doi: 10.1109/TCYB.2018.2859363.
9) M. Kang *et al.*, "Managing traditional solar greenhouse with CPSS: A just-for-fit philosophy," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3371–3380, Dec. 2018, doi: 10.1109/TCYB.2018.2858264.
10) H. Dong *et al.*, "Parallel intelligent systems for integrated high-speed railway operation control and dynamic scheduling," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3381–3389, Dec. 2018, doi: 10.1109/TCYB.2018.2852772.
11) L. Cao, H. Li, and Q. Zhou, "Adaptive intelligent control for nonlinear strict-feedback systems with virtual control coefficients and uncertain disturbances based on event-triggered mechanism," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3390–3402, Dec. 2018, doi: 10.1109/TCYB.2018.2865174.
12) W. Zou, Y. Xia, and H. Li, "Fault diagnosis of tennessee-eastman process using orthogonal incremental extreme learning machine based on driving amount," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3403–3410, Dec. 2018, doi: 10.1109/TCYB.2018.2830338.
13) Q. Zhang, L. Zhong, S. Gao, and X. Li, "Optimizing HIV interventions for multiplex social networks via partition-based random search," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3411–3419, Dec. 2018, doi: 10.1109/TCYB.2018.2853611.
14) C. Wu, Z. Hu, J. Liu, and L. Wu, "Secure estimation for cyber-physical systems via sliding mode," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3420–3431, Dec. 2018, doi: 10.1109/TCYB.2018.2825984.
15) X. Huang and J. Dong, "Reliable control policy of cyber-physical systems against a class of frequency-constrained sensor and actuator attacks," *IEEE Trans. Cybern.*, vol. 48, no. 12, pp. 3432–3439, Dec. 2018, doi: 10.1109/TCYB.2018.2815758.