Guest Editorial
Introduction to the Special Issue on Intelligent Transportation Systems in Epidemic Areas

THE COVID-19 pandemic has posed significant challenges to transportation systems in various aspects, such as transferring patients and medical resources, enforcing physical distancing in public transportation, and controlling virus transmission through transportation networks. To address these challenges, a variety of artificial intelligence technologies, such as autonomous driving, big data analytics, intelligent vehicle routing and scheduling, and intelligent traffic control, have been employed in the design of intelligent transportation systems. This Special Issue provides a forum for researchers and practitioners to present the most recent advances in presenting and applying intelligent technologies to promote transportation systems in large-scale epidemics.

A number of submissions were received in response to our open call for papers of the Special Issue. All these papers were rigorously evaluated according to the normal reviewing process of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS. The selection process considered criteria on originality, technical quality, as well as practical significance. Totally, 12 articles were selected after at least a double round of high-quality reviews.

In [A1], Li et al. proposed a multi-objective vehicle routing problem (VRP) model, named VRP4E, which takes into account not only the traditional travel cost but also the prevention cost in epidemic situations. To efficiently solve the problem, a novel multi-objective ant colony system algorithm was proposed and then verified on 25 benchmarks by comparing with six state-of-the-art methods. Moreover, the VRP4E in different epidemic situations and a real-world case in Beijing–Tianjin–Hebei region, China, were studied to provide helpful insights for combatting COVID-19-like epidemics.

In [A2], Wu et al. developed an improved variable neighborhood descent (IVND) algorithm by combining the metropolis acceptance criterion of Simulated Annealing (SA) and the tabu list of Tabu Search (TS), while K-means clustering and nearest neighbor strategy are integrated for generating initial solutions. The experiments were conducted by comparing IVND with VND, SA, TS, variants of VND, and large neighborhood search (LNS) on test and practical instances with different scales, and the results demonstrated the superior performance as well as the robustness of IVND.

For emergency preparedness in COVID-19, in [A3], Bi et al. developed a traffic control mechanism based on queueing theory to generate cooperative behaviors and optimize resource allocation in an urban transportation system. The experimental results showed that the introduction of the incentive-based traffic control mechanism can significantly reduce hazard response time, travel delay as well as the energy usage of the urban transportation system at the expense of monetary rewards.

In [A4], Lv et al. explored the effect of Digital Twins (DTs) in Unmanned Aerial Vehicles (UAVs) on providing medical resources quickly and accurately during COVID-19. A UAV DTs information forecasting model was constructed based on AlexNet, which can provide smaller transmission delays, lesser energy consumption in throughput demand, shorter task completion time, and higher resource utilization rate.

To predict the demand of urban ride-hailing for residents' healthy travel, rational platform operation, and traffic control during the epidemic period, in [A5], Huang et al. presented a deep-learning model, called MOS-BiAtten, based on encoder-decoder network with multi-head spatial attention mechanism and bidirectional attention mechanism. The proposed model was evaluated on the real-world dataset during COVID-19 in Beijing, and the experimental results demonstrate that MOS-BiAtten achieves a better performance compared with the state-of-art methods.

In [A6], Wang et al. developed a method to mine knowledge from raw Automation Identification System (AIS) data. First, berths are identified by improved density-based spatial clustering. Then, some data features, such as ship deadweight, arrival time, dwelling time, ship types, etc., can be extracted using information matching and statistical analysis. Next, the dynamic time warping method is employed to analyze abnormal ship behavior patterns and quantify the impacts of COVID-19. After that, a significance test is employed to determine an impact threshold through year-on-year analysis on ship flow, daily throughout and berthing time of quays. Finally, statistical analysis is used for the short-term impact analysis. A case study based on four-year AIS data in the Oslo port area showed that the proposed method can identify abnormal patterns caused by COVID-19 and estimate its impacts.

In the survey paper [A7], Karatas et al. investigated the emerging decision problematics observed during epidemics/pandemics under four research clusters, including 1) effects of epidemics on transportation, 2) effect of mobility on pandemic spread, 3) logistics and delivery systems, and 4) medical waste management and wastewater-based epidemiology. Next, they explored the operations research tools implemented to solve the transportation and location-related decision problems in each cluster.

To solve the adaptive traffic signal control (ATSC) problems in in epidemic regions, in [A8], Zhang et al. presented

Digital Object Identifier 10.1109/TITS.2022.3222974

a cooperative multiagent reinforcement learning framework, called neighborhood cooperative hysteretic deep Q-learning network (NC-HDQN), which analyses correlation degrees with their connected neighbors and weighs observations and rewards by these correlations. Two NC-HDQN methods used expert experience and Pearson coefficients to analyze correlation degrees with their connected neighbors, respectively. Evaluation on a synthetic scenario and two real-world traffic scenarios demonstrated the proposed method gave a better performance in almost every standard test metric for ATSC.

In [A9], Chen et al. proposed a hierarchical object association algorithm based on a two-level strategy. Besides, a refinement approach was designed to choose optimal object poses to improve the estimation of object pose as well as to enhance the accuracy of semantic maps. The experiments on both simulated and real hospitals demonstrated the superiority of the proposed approach over existing state-of-the-art methods in terms of association accuracy and trajectory errors.

In [A10], Liu et al. presented a depth-sensing and reconstruction system to address the lack of dense and accurate 360 depth datasets in the large-scale indoor environment. First, an omnidirectional depth completion convolutional neural network model was proposed to extract features from cross-modal omnidirectional input with unequal sparsity, and deal with the imbalanced data distribution and distortion in the panoramic input. Second, a 3D reconstruction system was designed to integrate the depth completion into omnidirectional localization and dense mapping. The proposed method was evaluated on 360D large-scale indoor datasets and real-world sequences of a challenging hospital scene. The experimental results demonstrated the superiority of the proposed method compared with the state-of-the-art approaches in terms of depth completion and 3D reconstruction.

In [A11], Wang et al. proposed a temporal–spatial aggregation embedding network (TSAEN) for multi-object tracking. The proposes network includes a temporal-aware correlation module (TACM) and spatial-aggregate embedding module (SAEM), which can fully obtain and aggregate appearance clues related to moving objects in previous frames. The TACM learns the temporal homogeneity features of the current and previous frames to perceive features with correlated appearance cues. Then, the SAEM adjusts the spatial deformation for each perceived temporal homogeneity feature and aggregates them for re-ID embedding learning. The experimental results demonstrated the superior performance of the proposed method.

In [A12], Zhou et al. proposed a heterogeneous deep reinforcement learning algorithm based on a graph attention network to navigate robots in dynamic environments, especially in crowd and epidemic situation. The algorithm encodes the constrained human–robot-coexisting environment in a heterogeneous graph with four types of nodes, and constructs an interactive agent-level representation for objects surrounding the robot. Also, it incorporates the dynamic constraints from the non-holonomic motion model into the deep reinforcement learning framework. The experimental results showed that the proposed method outperformed four baseline algorithms and can be easily migrated to real robots.

YU-JUN ZHENG, *Guest Editor*
School of Information Science and Technology
Hangzhou Normal University
Hangzhou 310030, China
e-mail: yujun.zheng@computer.org

HONGHAI LIU, *Guest Editor*
School of Computing
University of Portsmouth
PO1 2DJ Portsmouth, U.K.
e-mail: honghai.liu@icloud.com

HOUXIANG ZHANG, *Guest Editor*
Faculty of Engineering
Norwegian University of Science and Technology
7034 Trondheim, Norway
e-mail: hozh@ntnu.no

SHENGYONG CHEN, *Corresponding Guest Editor*
School of Computer Science and Engineering
Tianjin University of Technology
Tianjin 300387, China
e-mail: sy@ieee.org

APPENDIX: RELATED ARTICLES

[A1] J.-Y. Li et al., "A multipopulation multiobjective ant colony system considering travel and prevention costs for vehicle routing in COVID-19-like epidemics," *IEEE Trans. Intell. Transp. Syst.*, early access, Jun. 17, 2022, doi: 10.1109/TITS.2022.3180760.

[A2] G. Wu, N. Mao, Q. Luo, B. Xu, J. Shi, and P. N. Suganthan, "Collaborative truck-drone routing for contactless parcel delivery during the epidemic," *IEEE Trans. Intell. Transp. Syst.*, early access, Jun. 20, 2022, doi: 10.1109/TITS.2022.3181282.

[A3] H. Bi, W.-L. Shang, Y. Chen, K. Yu, and W. Y. Ochieng, "An incentive-based road traffic control mechanism for COVID-19 pandemic alike emergency preparedness and response," *IEEE Trans. Intell. Transp. Syst.*, early access, Jul. 25, 2022, doi: 10.1109/TITS.2022.3191161.

[A4] Z. Lv, D. Chen, H. Feng, H. Zhu, and H. Lv, "Digital twins in unmanned aerial vehicles for rapid medical resource delivery in epidemics," *IEEE Trans. Intell. Transp. Syst.*, early access, Sep. 29, 2021, doi: 10.1109/TITS.2021.3113787.

[A5] Z. Huang, D. Wang, Y. Yin, and X. Li, "A spatiotemporal bidirectional attention-based ride-hailing demand prediction model: A case study in Beijing during COVID-19," *IEEE Trans. Intell. Transp. Syst.*, early access, Nov. 1, 2021, doi: 10.1109/TITS.2021.3122541.

[A6] C. Wang, G. Li, P. Han, O. Osen, and H. Zhang, "Impacts of COVID-19 on ship behaviours in port area: An AIS data-based pattern recognition approach," *IEEE Trans. Intell. Transp. Syst.*, early access, Feb. 7, 2022, doi: 10.1109/TITS.2022.3147377.

[A7] M. Karatas, L. Eriskin, and E. Bozkaya, "Transportation and location planning during epidemics/pandemics: Emerging problems and solution approaches," *IEEE Trans. Intell. Transp. Syst.*, early access, Apr. 25, 2022, doi: 10.1109/TITS.2022.3166724.

[A8] C. Zhang et al., "Neighborhood cooperative multiagent reinforcement learning for adaptive traffic signal control in epidemic regions," *IEEE Trans. Intell. Transp. Syst.*, early access, May 13, 2022, doi: 10.1109/TITS.2022.3173490.

[A9] K. Chen, J. Liu, Q. Chen, Z. Wang, and J. Zhang, "Accurate object association and pose updating for semantic SLAM," *IEEE Trans. Intell. Transp. Syst.*, early access, May 23, 2022, doi: 10.1109/TITS.2021.3136918.

[A10] R. Liu, G. Zhang, J. Wang, and S. Zhao, "Cross-modal 360° depth completion and reconstruction for large-scale indoor environment," *IEEE Trans. Intell. Transp. Syst.*, early access, Mar. 14, 2022, doi: 10.1109/TITS.2022.3155925.

[A11] M. Wang et al., "An online multiobject tracking network for autonomous driving in areas facing epidemic," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 16, 2022, doi: 10.1109/TITS.2022.3195183.

[A12] Z. Zhou et al., "Navigating robots in dynamic environment with deep reinforcement learning," *IEEE Trans. Intell. Transp. Syst.*, early access, Oct. 25, 2022, doi: 10.1109/TITS.2022.3213604.

Yu-Jun Zheng (Senior Member, IEEE) received the Ph.D. degree in computer science from the Institute of Software, Chinese Academy of Sciences, in 2010. He is a Professor with Hangzhou Normal University. His research interests are intelligent computational methods and their applications in disaster rescue. He has authored over 100 papers in IEEE TRANSACTIONS and other famous journals. He is an Editorial Board Member of *Applied Soft Computing and International Journal of Bio-Inspired Computation*. He received the runner-up of IFORS Prize for Development due to the work on emergency scheduling of rescuing tasks in the 2013 Dingxi earthquake. In 2018, he was selected as a finalist of the Daniel H. Wagner Prize for Excellence in Operations Research Practice.

Honghai Liu (Fellow, IEEE) received the Ph.D. degree in robotics from King's College London, London, U.K., in 2003. He joined the University of Portsmouth, Portsmouth, U.K., in September 2005. He previously held research appointments at the Universities of London and Aberdeen, and project leader appointments in large-scale industrial control and system integration industry. He has published over 300 peer-reviewed international journals and conference papers. He is interested in approximate computation, pattern recognition, intelligent video analytics, and cognitive robotics and their practical applications with an emphasis on approaches which could make contribution to the intelligent connection of perception to action using contextual information. He is the recipient of four best paper awards.

Houxiang Zhang (Senior Member, IEEE) received the Habilitation degree in informatics from the University of Hamburg. He is currently a Full Professor of robotics and cybernetics at the Norwegian University of Science and Technology, Norway, since 2011. From 2011 to 2016, he held a gift professorship on product and system design from the industry. The focus of his research lies on biological robots, modular robotics, virtual prototyping, and maritime mechatronics. He has coordinated more than 20 projects supported by the Norwegian Research Council (NFR), German Research Council (DFG), and industry. He has published over 200 journal and conference papers and book chapters. He received four best paper awards at the robotic conferences, and four finalist awards for best conference paper at IEEE Robotics and Automation conferences. He is a fellow of Norwegian Academy of Sciences.

Shengyong Chen (Senior Member, IEEE) received the Ph.D. degree in computer vision from the City University of Hong Kong, Hong Kong, in 2003. He was with the University of Hamburg from 2006 to 2007. He worked as a Visiting Professor at Imperial College London and University of Cambridge, U.K. He is currently a Professor with the Tianjin University of Technology, China. He has over 100 patents and published over 400 scientific papers in international journals and conferences, with 50 in IEEE TRANSACTIONS. His research interests include autonomous robots, computer vision, and machine intelligence. He is an IET Fellow. He received the National Outstanding Youth Foundation Award of China in 2013. He received the IEEE Sensors Journal Best Paper Award in 2012 and the IET Premium Award in 2013. He received the Fellowship from the Alexander von Humboldt Foundation of Germany. He organized over 20 international conferences and serves as an Associate Editor of three international journals, e.g., IEEE TRANSACTIONS ON CYBERNETICS.