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Guest Editorial of the Special Section on Customers Centric Communication and Networked Control for Intelligent Cyber-Physical Transportation Systems

Transportation accidents and traffic congestion issues are among the biggest today challenges due to the presence of a large number of vehicles manufactured worldwide. The following problems faced by road transport like inadequate road networks, highly congested city roads, difficulties of pedestrians, unmetalled roads, poor bridge conditions, parking difficulties, atmospheric pollution, environmental impact, and violation of traffic rules respectfully. Efforts across the world for Intelligent Cyber-Physical Transportation Systems (ICTS) are focused on addressing a range of problems including minimizing traffic accidents and fuel consumption, less congestion, reducing time spent on traffic jams, and enhancing transportation safety. ICTS systems cover the whole transportation-based information through advanced Customer-centric communication and networked control methods, such as intervehicle, vehicle-to-roadside (V2R), and vehicle-to-vehicle (V2V) via vehicular ad hoc network (VANET) communications. Cutting-edge technologies like Customer-centric communication, control, embedded systems, Internet of things, wireless sensor networks, data analytics, computer vision, cyber-physical systems (CPS), blockchain, learning analytics, and artificial intelligence, etc., have paved the way for intelligent transportation system (ITS). The special issue will focus on the role of advanced Customer-centric communication and networked control systems in Intelligent transportation systems to provide holistic information about the real-time conditions of the subjects (users, vehicles, roads, traffic, etc.) and their surroundings so that informed decision may be taken based on the data captured by these sensors via CPS. It aims to present the most important and relevant advances to overcome the challenges related to CNC-ICTS analytics, and processing through IoT-CPS. Particularly, authors are encouraged to submit their original research and review articles in theoretical, methodological, or practical focuses, such as simulation models, algorithms, experiments, and applications for big complex transportation systems. Statistically, twenty-one manuscripts are published in this special issue that directly or indirectly work on communication and control-based intelligent cyber-physical systems with intelligent interfacing and implementation techniques.

The first paper by M. Obayya *et al.* [1] presents a complete study and awareness of the uses of Deep learning models on Intelligent Transportation Systems, as well as demonstrates the development in Intelligent Transportation Systems research that has been owing to Deep learning studies. This paper offers

a summary and taxonomy of current traffic forecast systems.

The second paper by H. Gupta *et al.* [2] proposes an artificial intelligence-based Anomalies detection scheme model employing a feature selection technique based on fuzzy and genetic algorithms and also uses the bio-inspired genetic algorithms Intelligent Water Drop and Biogeography-based Optimization for feature selection intending to detect malicious sessions in IoT networks.

The third paper by A. Chougule *et al.* [3] presents a Privacy-Preserving Asynchronous Federated Learning and vertical partitioning-based Algorithm that reduces the duration of idling at red lights and improves the fuel consumption of Intelligent Transportation Systems. Additionally, the authors introduce a technique that enhances the passing-vehicle ratio at the intersection and efficiently manages the traffic.

The fourth paper by H. N. AlEisa *et al.* [4] investigates whether deep learning can enhance the security of autonomous vehicles and other forms of smart transportation. Authors improve the smart transport network using the deep learning method, simulate it, and statistically study its data transmission economy, accuracy projections of the future, and path-switching strategy.

The fifth paper by M. A. Saleem *et al.* [5] proposes a secure access control protocol with conditional privacy for VANETs. Unlike other protocols, this protocol does not require the Trusted Authority's involvement during authentication between vehicles and roadside units. Additionally, this protocol leverages pseudonym mechanisms to provide conditional privacy, enabling legitimate vehicles to remain anonymous while malicious ones can be tracked. The authors propose scheme is supported by both formal and informal security analyses and is secure against several known attacks in VANETs.

The sixth paper by Q. V. Khanh *et al.* [6] develops an efficient routing scheme that aims to enhance the performance and reduce energy consumption of self-organizing networks for Intelligent Transportation Systems in smart cities with low mobility speeds. The simulation results clearly show that the proposed algorithm performs better than conventional routing protocols in low-speed mobility scenarios.

The seventh paper by Y. Zhang *et al.* [7] proposes a Dual

channel attention Graph Attention network, termed DDGAT. Specifically, the traffic channel builds a sequential-based graph, where words are nodes and their co-occurrences are edges. In contrast, the emotion channel builds a syntactic-based graph with words as nodes and semantic dependencies as edges.

The eighth paper by J. Huang *et al.* [8] designs an interference avoidance resource allocation strategy based on a hypergraph in customer-centric communication for Intelligent Cyber-physical Transportation Systems. The overlapping interference relationship between customers is modeled in the interference model by hypergraph theory, the interference avoidance resource allocation under complex interferences is generalized to a hypergraph vertex strong coloring problem.

The ninth paper by G. ALMahadin *et al.* [9] suggests a deep learning model for anomaly detection based on GRU over VANET network traffic to address this challenge. To further improve the accuracy of the proposed model, a new semi-supervised technique for detecting VANET network activity anomalies called SEMI-GRU has been proposed.

The tenth paper by H. Yan *et al.* [10] proposes a solution to the service caching problem in Intelligent Cyber-Physical Transportation Systems, named SFT-SCAR with the assistance of digital twins. A digital twins-supported service providing a framework for Intelligent Cyber-Physical Transportation Systems is designed. Then, a graph attention network-based service request flow prediction scheme and an asynchronous advantage actor-critic-based service caching scheme are presented. Besides, the generated caching strategies are simulated in the digital twins of Intelligent Cyber-Physical Transportation Systems to evaluate the performance of these strategies.

The eleventh paper by F. Ullah *et al.* [11] develops a novel network intrusion detection system for VANET that leverages Spark-based big data optimization and transfer learning. This paper delivers the best detection results for a variety of attacks including audio, HTTP, BruteForce, web, and others.

The twelfth paper by Q. Lai *et al.* [12] proposes a Feature attention mechanism to search and promote significant features. Furthermore, the Feed-Forward Network is replaced with a Routing module for a deeper but less-parameter network.

The thirteenth paper by Y. Ren *et al.* [13] presents a new path-tracking control method for autonomous ground vehicles. A novel fuzzy switching controller is designed, which can realize cooperative control of multiple fuzzy controllers according to specific switching rules by reading the change in vehicle speed.

The fourteenth paper by J. He *et al.* [14] propose an Autonomous Underwater Vehicle On-board Control Scheme based on multi-agent reinforcement learning and cloud computing technology to serve consumer-level Autonomous Underwater Vehicles, in which the local perception information

preprocessed by each Autonomous Underwater Vehicle is uploaded to the cloud center for data fusion in real-time and a centralized value function is designed to optimize the global decision.

The fifteenth paper by H. Peng *et al.* [15] proposes an ambient backscatter communication symbiotic ITS. To evaluate the system performance, we derive the expressions in terms of detection error probability, outage probability, effective covert rate, and energy efficiency.

The sixteenth paper by P. Liu *et al.* [16] establishes the characteristics of the vertical parking process and C-type parking constraints, a two-stage vertical parking dynamic optimization problem. Simulation experiments show that the proposed method can effectively obtain vertical parking trajectories with fast computation and good adaptability.

The seventeenth paper by F. Hasan *et al.* [17] focuses intention awareness on two data sources and has also implemented the multi-head attention mechanism to achieve interaction awareness to achieve accurate future trajectory predictions. The proposed method has been trained and evaluated with publicly available datasets.

The eighteenth paper by P. Liu *et al.* [18] integrates Federated Learning into a Multimodal Deep Learning framework to protect participants' privacy while achieving better performance in recommending driver breaks. The experimental findings demonstrate that the proposed method not only outperforms other existing approaches in terms of providing effective driver break recommendations but also prioritizes the privacy of the individuals involved.

The nineteenth paper by D. Cao *et al.* [19] focuses on a new Reservation-Based Multi-Source Distributed Offloading strategy. To minimize the long-term average task completion latency of the system, this strategy employs a Greedy Randomized Adaptive Search Procedures framework in dealing with the problem of multi-source tasks competing for limited computing resources and uses the reservation-based Sequential Quadratic Programming algorithm to achieve unequal task segmentation to maximize system performance.

The twentieth paper by C. Tang *et al.* [20] presents the optimization problem into per-slot optimization subproblems. The authors propose an effective algorithm with low time complexity to solve these subproblems in a slot-by-slot manner and evaluate the performance of our approach through extensive simulations, demonstrating that our method outperforms the baseline approaches in various aspects.

The final paper by M. Aljebreen *et al.* [21] provides a robust traffic prediction solution with direct applications in smart cities and real-time traffic management. To evaluate the model's efficacy, the author conducted an empirical case study using the Enhanced Next Generation Simulation dataset, which

offers highly granular vehicle trajectory data.

All twenty-one papers tackle different but extremely relevant domain problems of communication and control, and intelligent cyber-physical systems in the context of Consumer Electronics. We hope the special Issue will raise awareness in the scientific community, by presenting and highlighting the advances and latest novel and emerging technologies, implementations, and applications. We thank the authors and the reviewers for their contribution to this Special Section. We are grateful to the Editor-in-Chief for having allowed us to serve as Guest Editors and for his guidance throughout the whole process.

APPENDIX: RELATED ARTICLES

- [1] M. Obayya *et al.*, "Artificial Intelligence for Traffic Prediction and Estimation in Intelligent Cyber-Physical Transportation Systems," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3320513.
- [2] H. Gupta, S. Sharma and S. Agrawal, "Artificial Intelligence-Based Anomalies Detection Scheme for Identifying Cyber Threat on IoT-Based Transport Network," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3329253.
- [3] A. Chougule, V. Chamola, V. Hassija, P. Gupta and F. R. Yu, "A Novel Framework for Traffic Congestion Management at Intersections Using Federated Learning and Vertical partitioning," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3320362.
- [4] H. N. AlEisa *et al.*, "Transforming Transportation: Safe & Secure Vehicular Communication & Anomaly Detection with Intelligent Cyber-Physical System & Deep Learning," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3325827.
- [5] M. A. Saleem *et al.*, "Provably Secure Conditional-Privacy Access Control Protocol for Intelligent Customers-centric Communication in VANET," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3324273.
- [6] Q. V. Khanh, A. Chehri, Q. N. Minh, V. -H. Nguyen and N. T. Ban, "An Efficient Routing Algorithm for Self-Organizing Networks in 5G-based Intelligent Transportation Systems," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3329390.
- [7] Y. Zhang, Y. He, R. Chen, P. Tiwari, A. E. Saddik and M. S. Hossain, "A Dual Channel Cyber-Physical Transportation Network for Detecting Traffic Incidents and Driver Emotion," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3325335.
- [8] J. Huang *et al.*, "Hypergraph-Based Interference Avoidance Resource Management in Customer-Centric Communication for Intelligent Cyber-physical Transportation Systems," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3324680.
- [9] G. AlMahadin *et al.*, "VANET Network Traffic Anomaly Detection Using GRU-Based Deep Learning Model," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3326384.
- [10] H. Yan, X. Xu, M. Bilal, X. Xia, W. Dou and H. Wang, "Customer Centric Service Caching for Intelligent Cyber-Physical Transportation Systems with Cloud-Edge Computing Leveraging Digital Twins," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3326969.
- [11] F. Ullah, G. Srivastava, S. Ullah, K. Yoshigoe and Y. Zhao, "NIDS-VSB: Network Intrusion Detection System for VANET using Spark-Based Big Data Optimization and Transfer Learning," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3328320.
- [12] Q. Lai *et al.*, "Improved Transformer-based Privacy-Preserving Architecture for Intrusion Detection in Secure V2X Communications," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3324081.
- [13] Y. Ren, X. Xie, J. Wu and J. Xia, "Enhanced H ∞ Tracking Control of Autonomous Ground Vehicles via A Novel Fuzzy Switching Controller," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3342140.
- [14] J. He *et al.*, "An On-Board Control Scheme for Consumer-Level Autonomous Underwater Vehicle in the Intelligent Cyber-Physical Transportation Systems," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3332587.
- [15] H. Peng *et al.*, "Ambient Backscatter Communication Symbiotic Intelligent Transportation Systems: Coverters Performance Analysis and Optimization," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3329675.
- [16] P. Liu, Z. Chen, M. Liu, C. Piao, K. Wan and H. Huang, "Vertical Parking Trajectory Planning with the Combination of Numerical Optimization Method and Gradient Lifting Decision Tree," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3321109.
- [17] F. Hasan and H. Huang, "Driver Intention & Interaction-Aware Trajectory Forecasting via Modular Multi-Task Learning," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3321324.
- [18] P. Liu, L. Jiang, H. Lin, J. Hu, S. Garg and M. Alrashoud, "Federated Multimodal Learning for Privacy-Preserving Driver Break Recommendations in Consumer Electronics," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3339630.
- [19] D. Cao *et al.*, "A Reservation-Based Multi-Source Distributed Offloading Strategy in Dynamic Environments," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3338745.
- [20] C. Tang, G. Yan, H. Wu and C. Zhu, "Computation Offloading and Resource Allocation in Failure-Aware Vehicular Edge Computing," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3342017.
- [21] M. Aljebreen *et al.*, "Enhancing Traffic Flow Prediction in Intelligent Cyber-Physical Systems: A Novel Bi-LSTM-Based Approach with Kalman Filter Integration," in *IEEE Transactions on Consumer Electronics*, doi: 10.1109/TCE.2023.3335155.

Best wishes,

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Houbing Herbert Song (M'12–SM'14–F'23) received the Ph.D. degree in electrical engineering from the University of Virginia, Charlottesville, VA, in August 2012. He is currently a Professor, the Founding Director of the NSF Center for Aviation Big Data Analytics (Planning), the Associate Director for Leadership of the DOT Transportation Cybersecurity Center for Advanced Research and Education (Tier 1 Center), and the Director of the Security and Optimization for Networked Globe Laboratory (SONG Lab, www.SONGLab.us), University of Maryland, Baltimore County (UMBC), Baltimore, MD. He serves as an Associate Editor for IEEE Transactions on Artificial Intelligence (TAI) (2023-present), IEEE Internet of Things Journal (2020-present), IEEE Transactions on Intelligent Transportation Systems (2021-present), and IEEE Journal on Miniaturization for Air and Space Systems (J-MASS) (2020-present). Dr. Song is an [IEEE Fellow](#) (for contributions to big data analytics and integration of AI with Internet of Things), an American Association for the Advancement of Science (AAAS) Fellow, an [Asia-Pacific Artificial Intelligence Association \(AAIA\) Fellow](#), an [ACM Distinguished Member](#) (for outstanding scientific contributions to computing), and a Full Member of Sigma Xi. Dr. Song has been a [Highly Cited Researcher](#) identified by Web of Science since 2021. He is an [ACM Distinguished Speaker](#) (2020-present), an

IEEE [Communications Society \(ComSoc\) Distinguished Lecturer](#) (2024-present), an IEEE [Vehicular Technology Society \(VTS\) Distinguished Lecturer](#) (2023-present) and an IEEE [Systems Council Distinguished Lecturer](#) (2023-present). Dr. Song received [Research.com Rising Star of Science Award](#) in 2022, [2021 Harry Rowe Mimno Award](#) bestowed by IEEE Aerospace and Electronic Systems Society, and 10+ Best Paper Awards from major international conferences.

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