参考文献

- [1] 国家统计局. 中华人民共和国 2021 年国民经济和社会发展统计公报[R/OL]. (2022-02-28) [2023-04-20]. http://www.gov.cn/xinwen/2022-02/28/content_5676015.htm.
- [2] 世界卫生组织. 道路交通伤害[EB/OL]. [2023-04-20]. https://www.who.int/zh/news-room/fact-sheets/detail/road-traffic-injuries.
- [3] 生态环境部. 中国移动源环境管理年报[R/OL]. (2022-12-07)[2023-04-20]. https://www.mee.gov.cn/hjzl/sthjzk/ydyhjgl/202212/W020221207387013521948.pdf.
- [4] 中共中央, 国务院. 交通强国建设纲要[R/OL]. (2019-09-19)[2022-04-20]. http://www.gov.cn/zhengce/2019-09/19/content_5431432.htm.
- [5] 国家发展和改革委员会,中央网信办,科技部,等. 智能汽车创新发展战略[R/OL]. (2020-02-24)[2023-04-20]. https://www.ndrc.gov.cn/xxgk/zcfb/tz/202002/P020200224573058971435.pdf.
- [6] 科技部. 科技部关于支持建设新一代人工智能示范应用场景的通知[EB/OL]. [2023-04-20]. https://www.most.gov.cn/xxgk/xinxifenlei/fdzdgknr/qtwj/qtwj2022/202208/t20220815_181874.html.
- [7] WANG J, GUO J, LUO Y, et al. Design of switching controller for connected vehicles platooning with intermittent communication via mode-dependent average dwell-time approach[J]. IEEE Internet of Things Journal, 2023, 10(3): 2708-2719.
- [8] LI S E, ZHENG Y, LI K, et al. Dynamical modeling and distributed control of connected and automated vehicles: Challenges and opportunities[J]. IEEE Intelligent Transportation Systems Magazine, 2017, 9(3): 46-58.
- [9] ZHENG Y, EBEN LI S, WANG J, et al. Stability and scalability of homogeneous vehicular platoon: Study on the influence of information flow topologies[J]. IEEE Transactions on Intelligent Transportation Systems, 2016, 17(1): 14-26.
- [10] LI B, CAO D, TANG S, et al. Sharing traffic priorities via cyber–physical–social intelligence: A lane-free autonomous intersection management method in metaverse[J]. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 2023, 53(4): 2025-2036.
- [11] LIU T, XING Y, TANG X, et al. Cyber-physical-social system for parallel driving: From concept to application[J]. IEEE Intelligent Transportation Systems Magazine, 2021, 13(1): 59-69.
- [12] LV W, LV Y, MALIKOPOULOS A A, et al. Guest editorial special issue on big data and AI for computational transportation in the cyber–physical–social space[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 22(12): 7887-7890.
- [13] CHEN S, HU J, ZHAO L, et al. Cellular vehicle-to-everything (C-V2X)[M]. London: Springer Nature, 2023.
- [14] CHEN S, HU J, SHI Y, et al. A vision of C-V2X: Technologies, field testing, and challenges with Chinese development[J]. IEEE Internet of Things Journal, 2020, 7(5): 3872-3881.

- [15] CHEN S, HU J, SHI Y, et al. Vehicle-to-everything (V2X) services supported by LTE-based systems and 5G[J]. IEEE Communications Standards Magazine, 2017, 1(2): 70-76.
- [16] ZHANG D G, ZHU H L, ZHANG T, et al. A new method of content distribution based on fuzzy logic and coalition graph games for VEC[J]. Cluster Computing, 2023: 701-717.
- [17] HAO L, HUANG B, JIA B, et al. DHCLoc: A device-heterogeneity-tolerant and channel-adaptive passive WiFi localization method based on DNN[J]. IEEE Internet of Things Journal, 2022, 9(7): 4863-4874.
- [18] YUE W, LI C, WANG S, et al. Towards enhanced recovery and system stability: Analytical solutions for dynamic incident effects in road networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(1): 483-498.
- [19] SUNC, LIX, WEN J, et al. Federated deep reinforcement learning for recommendation-enabled edge caching in mobile edge-cloud computing networks[J]. IEEE Journal on Selected Areas in Communications, 2023, 41(3): 690-705.
- [20] JU Y, CHEN Y, CAO Z, et al. Joint secure offloading and resource allocation for vehicular edge computing network: A multi-agent deep reinforcement learning approach[J]. IEEE Transactions on Intelligent Transportation Systems, 2023: 1-15.
- [21] WANG Y, HE Y, RICHARD YU F, et al. Efficient resource allocation in multi-UAV assisted vehicular networks with security constraint and attention mechanism[J]. IEEE Transactions on Wireless Communications, 2022: 1-14.
- [22] FANG Y, MIN H, LEI X, et al. A self-fault diagnosis framework for sensors of connected and automated vehicles with dynamic environmental impact quantification[C]//Proceedings of IEEE International Conference on Intelligent Transportation Systems (ITSC). Macau, China: IEEE, 2022: 422-427.
- [23] FANG Y, MIN H, WU X, et al. On-ramp merging strategies of connected and automated vehicles considering communication delay[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(9): 15298-15312.
- [24] JING S, HUI F, ZHAO X, et al. Integrated longitudinal and lateral hierarchical control of cooperative merging of connected and automated vehicles at on-ramps[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(12): 24248-24262.
- [25] CHEN J, WU H, LYU F, et al. Adaptive resource allocation for diverse safety message transmissions in vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(8): 13482-13497.
- [26] LIU M, LI D, WU H, et al. Real-time search-driven caching for sensing data in vehicular networks[J]. IEEE Internet of Things Journal, 2022, 9(14): 12219-12230.
- [27] LI J, SHI W, WU H, et al. Cost-aware dynamic SFC mapping and scheduling in SDN/NFV-enabled space air ground-integrated networks for internet of vehicles[J]. IEEE Internet of Things Journal, 2022, 9(8): 5824-5838.
- [28] DAI Y, ZHANG Y. Adaptive digital twin for vehicular edge computing and networks[J]. Journal

- of Communications and Information Networks, 2022, 7(1): 48-59.
- [29] ZHANG K, CAO J, MAHARJAN S, et al. Digital twin empowered content caching in social-aware vehicular edge networks[J]. IEEE Transactions on Computational Social Systems, 2022, 9(1): 239-251.
- [30] SUN W, WANG P, XU N, et al. Dynamic digital twin and distributed incentives for resource allocation in aerial-assisted internet of vehicles[J]. IEEE Internet of Things Journal, 2022, 9(8): 5839-5852.
- [31] YANG A, WENG J, YANG K, et al. Delegating authentication to edge: A decentralized authentication architecture for vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(2): 1284-1298.
- [32] DAI X, XIAO Z, JIANG H, et al. A learning-based approach for vehicle-to-vehicle computation offloading[J]. IEEE Internet of Things Journal, 2023, 10(8): 7244-7258.
- [33] YANG L, ZHANG L, HE Z, et al. Efficient hybrid data dissemination for edge-assisted automated driving[J]. IEEE Internet of Things Journal, 2020, 7(1): 148-159.
- [34] QI W, SONG Q, GUO L, et al. Energy-efficient resource allocation for UAV-assisted vehicular networks with spectrum sharing[J]. IEEE Transactions on Vehicular Technology, 2022, 71(7): 7691-7702.
- [35] IRANMANESH S, ABKENAR F S, JAMALIPOUR A, et al. A heuristic distributed scheme to detect falsification of mobility patterns in internet of vehicles[J]. IEEE Internet of Things Journal, 2022, 9(1): 719-727.
- [36] ALAM M Z, JAMALIPOUR A. Multi-agent DRL-based hungarian algorithm (MADRLHA) for task offloading in multi-access edge computing internet of vehicles (IoVs)[J]. IEEE Transactions on Wireless Communications, 2022, 21(9): 7641-7652.
- [37] KHAN L U, MUSTAFA E, SHUJA J, et al. Federated learning for digital twin-based vehicular networks: Architecture and challenges[J]. IEEE Wireless Communications, 2023: 1-8.
- [38] ZHANG H, LU C, TANG H, et al. Mean-field-aided multiagent reinforcement learning for resource allocation in vehicular networks[J]. IEEE Internet of Things Journal, 2023, 10(3): 2667-2679.
- [39] KANG Y, LIU S, ZHANG H, et al. Joint sensing task assignment and collision-free trajectory optimization for mobile vehicle networks using mean-field games[J]. IEEE Internet of Things Journal, 2021, 8(10): 8488-8503.
- [40] ALLADI T, AGRAWAL A, GERA B, et al. Ambient intelligence for securing intelligent vehicular networks: Edge-enabled intrusion and anomaly detection strategies[J]. IEEE Internet of Things Magazine, 2023, 6(1): 128-132.
- [41] LIANG H, ZHU L, YU F R, et al. A cross-layer defense method for blockchain empowered CBTC systems against data tampering attacks[J]. IEEE Transactions on Intelligent Transportation Systems, 2023, 24(1): 501-515.
- [42] BAI X, CHEN S, SHI Y, et al. Detection and defence method of low-rate DDoS attacks in

- vehicle edge computing network using information metrics[J]. International Journal of Sensor Networks, 2022, 40(1): 20-33.
- [43] WANG X, NING Z, GUO S, et al. Imitation learning enabled task scheduling for online vehicular edge computing[J]. IEEE Transactions on Mobile Computing, 2022, 21(2): 598-611.
- [44] REN Y, CHEN X, GUO S, et al. Blockchain-based VEC network trust management: A DRL algorithm for vehicular service offloading and migration[J]. IEEE Transactions on Vehicular Technology, 2021, 70(8): 8148-8160.
- [45] WANG Z, JIN S, LIU L, et al. Design of intelligent connected cruise control with vehicle-to-vehicle communication delays[J]. IEEE Transactions on Vehicular Technology, 2022, 71(8): 9011-9025.
- [46] TANG F, KAWAMOTO Y, KATO N, et al. Future intelligent and secure vehicular network toward 6G: Machine-learning approaches[J]. Proceedings of the IEEE, 2020, 108(2): 292-307.
- [47] ZHU Y, MAO B, KATO N. Intelligent reflecting surface in 6G vehicular communications: A survey[J]. IEEE Open Journal of Vehicular Technology, 2022, 3: 266-277.
- [48] LIU J, GUO H, XIONG J, et al. Smart and resilient EV charging in SDN-enhanced vehicular edge computing networks[J]. IEEE Journal on Selected Areas in Communications, 2020, 38 (1): 217-228.
- [49] HE Y, MA L, JIANG Z, et al. VI-eye: semantic-based 3D point cloud registration for infrastructure-assisted autonomous driving[C]//Proceedings of Annual International Conference on Mobile Computing and Networking (MobiCom). New Orleans: Association for Computing Machinery, 2021: 573-586.
- [50] SHI S, CUI J, JIANG Z, et al. VIPS: Real-time perception fusion for infrastructure-assisted autonomous driving[C]//Proceedings of Annual International Conference on Mobile Computing and Networking (MobiCom). New York: Association for Computing Machinery, 2022: 133–146.
- [51] FOUNDATION N S. Research initiative on cyber-physical systems[EB/OL]. [2023-04-20]. https://web.archive.org/web/20080517071555/http://varma.ece.cmu.edu/cps/.
- [52] LEE E A, SESHIA S A. Introduction to embedded systems: A cyber-physical systems approach [M]. Cambridge, Massachusetts: MIT Press, 2016.
- [53] LI X, YU X, WAGH A, et al. Human factors-aware service scheduling in vehicular cyber-physical systems[C]//Proceedings of IEEE International Conference on Computer Communications (INFOCOM). Shanghai, China: IEEE, 2011: 2174-2182.
- [54] 夏元清, 闫策, 王笑京, 等. 智能交通信息物理融合云控制系统[J]. 自动化学报, 2019, 45 (1): 132-142.
- [55] 中国信通院. 车联网白皮书[R/OL]. (2021-12-24)[2022-04-20]. http://www.caict.ac.cn/kxyj/qwfb/bps/202112/P020211224634954242855.pdf.
- [56] WU X, SUBRAMANIAN S, GUHA R, et al. Vehicular communications using DSRC: Challenges, enhancements, and evolution[J]. IEEE Journal on Selected Areas in Communications,

- 2013, 31(9): 399-408.
- [57] CHEN S, HU J, SHI Y, et al. LTE-V: A TD-LTE-based V2X solution for future vehicular network[J]. IEEE Internet of Things Journal, 2016, 3(6): 997-1005.
- [58] SAAD M M, KHAN M T R, SHAH S H A, et al. Advancements in vehicular communication technologies: C-V2X and NR-V2X comparison[J]. IEEE Communications Magazine, 2021, 59(8): 107-113.
- [59] 陈山枝, 胡金玲, 赵丽, 等. 蜂窝车联网(C-V2X)[M]. 北京: 人民邮电出版社, 2021.
- [60] LIU K, NG J K, LEE V C, et al. Cooperative data scheduling in hybrid vehicular ad hoc networks: VANET as a software defined network[J]. IEEE/ACM Transactions on Networking, 2016, 24(3): 1759-1773.
- [61] DAI P, LIU K, WU X, et al. Cooperative temporal data dissemination in SDN-based heterogeneous vehicular networks[J]. IEEE Internet of Things Journal, 2018, 6(1): 72-83.
- [62] LUO G, LI J, ZHANG L, et al. sdnMAC: A software-defined network inspired MAC protocol for cooperative safety in VANETs[J]. IEEE Transactions on Intelligent Transportation Systems, 2018, 19(6): 2011-2024.
- [63] LIU K, FENG L, DAI P, et al. Coding-assisted broadcast scheduling via memetic computing in SDN-based vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2018, 19(8): 2420-2431.
- [64] ZHANG X, ZHONG H, CUI J, et al. AC-SDVN: An access control protocol for video multicast in software defined vehicular networks[J]. IEEE Transactions on Mobile Computing, 2022: 1-18.
- [65] ZHAO L, BI Z, HAWBANI A, et al. ELITE: An intelligent digital twin-based hierarchical routing scheme for softwarized vehicular networks[J]. IEEE Transactions on Mobile Computing, 2022: 1-18.
- [66] LIN N, ZHAO D, ZHAO L, et al. ALPS: An adaptive link-state perception scheme for softwaredefined vehicular networks[J]. IEEE Transactions on Vehicular Technology, 2023, 72(2): 2564-2575.
- [67] AHMED U, LIN J C W, SRIVASTAVA G, et al. Deep active learning intrusion detection and load balancing in software-defined vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2023, 24(1): 953-961.
- [68] MAO Y, YOU C, ZHANG J, et al. A survey on mobile edge computing: The communication perspective[J]. IEEE Communications Surveys & Tutorials, 2017, 19(4): 2322-2358.
- [69] LIU J, WAN J, ZENG B, et al. A scalable and quick-response software defined vehicular network assisted by mobile edge computing[J]. IEEE Communications Magazine, 2017, 55(7): 94-100.
- [70] LANG P, TIAN D, DUAN X, et al. Cooperative computation offloading in blockchain-based vehicular edge computing networks[J]. IEEE Transactions on Intelligent Vehicles, 2022, 7(3): 783-798.
- [71] LIU K, XIAO K, DAI P, et al. Fog computing empowered data dissemination in software defined

- heterogeneous VANETs[J]. IEEE Transactions on Mobile Computing, 2021, 20(11): 3181-3193.
- [72] DAI P, SONG F, LIU K, et al. Edge intelligence for adaptive multimedia streaming in heterogeneous internet of vehicles[J]. IEEE Transactions on Mobile Computing, 2021, 22(3): 1464-1478.
- [73] LIU C, LIU K, GUO S, et al. Adaptive offloading for time-critical tasks in heterogeneous internet of vehicles[J]. IEEE Internet of Things Journal, 2020, 7(9): 7999-8011.
- [74] LIAO H, ZHOU Z, KONG W, et al. Learning-based intent-aware task offloading for air-ground integrated vehicular edge computing[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 22(8): 5127-5139.
- [75] LIU L, ZHAO M, YU M, et al. Mobility-aware multi-hop task offloading for autonomous driving in vehicular edge computing and networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2023, 24(2): 2169-2182.
- [76] LIU L, FENG J, MU X, et al. Asynchronous deep reinforcement learning for collaborative task computing and on-demand resource allocation in vehicular edge computing[J]. IEEE Transactions on Intelligent Transportation Systems, 2023: 1-14.
- [77] ZHANG Y, CHU L, OU Y, et al. A cyber-physical system-based velocity-profile prediction method and case study of application in plug-in hybrid electric vehicle[J]. IEEE Transactions on Cybernetics, 2021, 51(1): 40-51.
- [78] ALBABA B M, YILDIZ Y. Driver modeling through deep reinforcement learning and behavioral game theory[J]. IEEE Transactions on Control Systems Technology, 2021, 30(2): 885-892.
- [79] ZHANG T, ZOU Y, ZHANG X, et al. Data-driven based cruise control of connected and automated vehicles under cyber-physical system framework[J]. IEEE Transactions on Intelligent Transportation Systems, 2020, 22(10): 6307-6319.
- [80] ZHOU J, DAI H N, WANG H, et al. Wide-attention and deep-composite model for traffic flow prediction in transportation cyber-physical systems[J]. IEEE Transactions on Industrial Informatics, 2021, 17(5): 3431-3440.
- [81] LI C, ZHANG H, ZHANG T, et al. Cyber-physical scheduling for predictable reliability of inter-vehicle communications[J]. IEEE Transactions on Vehicular Technology, 2020, 69(4): 4192-4206.
- [82] LIAN Y, YANG Q, XIE W, et al. Cyber-physical system-based heuristic planning and scheduling method for multiple automatic guided vehicles in logistics systems[J]. IEEE Transactions on Industrial Informatics, 2021, 17(11): 7882-7893.
- [83] HU X, WANG H, TANG X. Cyber-physical control for energy-saving vehicle following with connectivity[J]. IEEE Transactions on Industrial Electronics, 2017, 64(11): 8578-8587.
- [84] DAI P, LIU K, ZHUGE Q, et al. A convex optimization based autonomous intersection control strategy in vehicular cyber-physical systems[C]//Proceedings of IEEE International Conference on Ubiquitous Intelligence and Computing (UIC). Toulouse, France: IEEE, 2016: 203-210.

- [85] LV C, HU X, SANGIOVANNI-VINCENTELLI A, et al. Driving-style-based codesign optimization of an automated electric vehicle: A cyber-physical system approach[J]. IEEE Transactions on Industrial Electronics, 2018, 66(4): 2965-2975.
- [86] DONG J, CHEN S, LI Y, et al. Spatio-weighted information fusion and DRL-based control for connected autonomous vehicles[C]//Proceedings of IEEE International Conference on Intelligent Transportation Systems (ITSC). Virtual Conference: IEEE, 2020: 1-6.
- [87] ZHAO Y, LIU C H. Social-aware incentive mechanism for vehicular crowdsensing by deep reinforcement learning[J]. IEEE Transactions on Intelligent Transportation Systems, 2020, 22 (4): 2314-2325.
- [88] MLIKA Z, CHERKAOUI S. Deep deterministic policy gradient to minimize the age of information in cellular V2X communications[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(12): 23597-23612.
- [89] LIU K, LEE V C S, NG J K Y, et al. Temporal data dissemination in vehicular cyber-physical systems[J]. IEEE Transactions on Intelligent Transportation Systems, 2014, 15(6): 2419-2431.
- [90] DAI P, LIU K, FENG L, et al. Temporal information services in large-scale vehicular networks through evolutionary multi-objective optimization[J]. IEEE Transactions on Intelligent Transportation Systems, 2019, 20(1): 218-231.
- [91] LIU K, LEE V C S, NG J K Y, et al. Scheduling temporal data with dynamic snapshot consistency requirement in vehicular cyber-physical systems[J]. ACM Transactions on Embedded Computing Systems, 2014, 13(5s): 1-21.
- [92] RAGER S T, CIFTCIOGLU E N, RAMANATHAN R, et al. Scalability and satisfiability of quality-of-information in wireless networks[J]. IEEE/ACM Transactions on Networking, 2017, 26(1): 398-411.
- [93] YOON D D, AYALEW B, ALI G G M N. Performance of decentralized cooperative perception in V2V connected traffic[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(7): 6850-6863.
- [94] NOOR-A-RAHIM M, LIU Z, LEE H, et al. A survey on resource allocation in vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(2): 701-721.
- [95] HE Y, WANG Y, LIN Q, et al. Meta-hierarchical reinforcement learning (MHRL)-based dynamic resource allocation for dynamic vehicular networks[J]. IEEE Transactions on Vehicular Technology, 2022, 71(4): 3495-3506.
- [96] LU H, ZHANG Y, LI Y, et al. User-oriented virtual mobile network resource management for vehicle communications[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 22 (6): 3521-3532.
- [97] PENG H, SHEN X. Deep reinforcement learning based resource management for multi-access edge computing in vehicular networks[J]. IEEE Transactions on Network Science and Engineering, 2020, 7(4): 2416-2428.
- [98] WEI W, YANG R, GU H, et al. Multi-objective optimization for resource allocation in vehicular

- cloud computing networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(12): 25536-25545.
- [99] PENG H, SHEN X. Multi-agent reinforcement learning based resource management in MECand UAV-assisted vehicular networks[J]. IEEE Journal on Selected Areas in Communications, 2021, 39(1): 131-141.
- [100] PATEL D K, SHAH H, DING Z, et al. Performance analysis of NOMA in vehicular communications over i.n.i.d nakagami-m fading channels[J]. IEEE Transactions on Wireless Communications, 2021, 20(10): 6254-6268.
- [101] ZHANG F, WANG M M, BAO X, et al. Centralized resource allocation and distributed power control for NOMA-integrated NR V2X[J]. IEEE Internet of Things Journal, 2021, 8(22): 16522-16534.
- [102] ZHU H, WU Q, WU X J, et al. Decentralized power allocation for MIMO-NOMA vehicular edge computing based on deep reinforcement learning[J]. IEEE Internet of Things Journal, 2022, 9(14): 12770-12782.
- [103] LIU Y, ZHANG H, LONG K, et al. Energy-efficient subchannel matching and power allocation in NOMA autonomous driving vehicular networks[J]. IEEE Wireless Communications, 2019, 26(4): 88-93.
- [104] LIU C, LIU K, REN H, et al. RtDS: Real-time distributed strategy for multi-period task offloading in vehicular edge computing environment[J]. Neural Computing and Applications, 2021: 1-15.
- [105] SHANG B, LIU L, TIAN Z. Deep learning-assisted energy-efficient task offloading in vehicular edge computing systems[J]. IEEE Transactions on Vehicular Technology, 2021, 70(9): 9619-9624.
- [106] LIU Z, DAI P, XING H, et al. A distributed algorithm for task offloading in vehicular networks with hybrid fog/cloud computing[J]. IEEE Transactions on Systems, Man, and Cybernetics, 2022, 52(7): 4388-4401.
- [107] CHEN M, GUO S, LIU K, et al. Robust computation offloading and resource scheduling in cloudlet-based mobile cloud computing[J]. IEEE Transactions on Mobile Computing, 2020, 20 (5): 2025-2040.
- [108] PAN C, WANG Z, LIAO H, et al. Asynchronous federated deep reinforcement learning-based URLLC-aware computation offloading in space-assisted vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022: 1-13.
- [109] ZHU Y, MAO B, KATO N. A dynamic task scheduling strategy for multi-access edge computing in IRS-aided vehicular networks[J]. IEEE Transactions on Emerging Topics in Computing, 2022, 10(4): 1761-1771.
- [110] ZHANG K, CAO J, ZHANG Y. Adaptive digital twin and multiagent deep reinforcement learning for vehicular edge computing and networks[J]. IEEE Transactions on Industrial Informatics, 2021, 18(2): 1405-1413.

- [111] HE Y, WANG Y, YU F R, et al. Efficient resource allocation for multi-beam satellite-terrestrial vehicular networks: A multi-agent actor-critic method with attention mechanism[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 23(3): 2727-2738.
- [112] CUI Y, DU L, WANG H, et al. Reinforcement learning for joint optimization of communication and computation in vehicular networks[J]. IEEE Transactions on Vehicular Technology, 2021, 70(12): 13062-13072.
- [113] HAN X, TIAN D, SHENG Z, et al. Reliability-aware joint optimization for cooperative vehicular communication and computing[J]. IEEE Transactions on Intelligent Transportation Systems, 2020, 22(8): 5437-5446.
- [114] XU L, YANG Z, WU H, et al. Socially driven joint optimization of communication, caching, and computing resources in vehicular networks[J]. IEEE Transactions on Wireless Communications, 2021, 21(1): 461-476.
- [115] DAI P, HU K, WU X, et al. Asynchronous deep reinforcement learning for data-driven task offloading in MEC-empowered vehicular networks[C]//Proceedings of IEEE International Conference on Computer Communications (INFOCOM). Virtual Conference: IEEE, 2021: 1-10.
- [116] DAI P, HU K, WU X, et al. A probabilistic approach for cooperative computation offloading in mec-assisted vehicular networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(2): 899-911.
- [117] NIE Y, ZHAO J, GAO F, et al. Semi-distributed resource management in UAV-aided MEC systems: A multi-agent federated reinforcement learning approach[J]. IEEE Transactions on Vehicular Technology, 2021, 70(12): 13162-13173.
- [118] WANG S, LEI T, ZHANG L, et al. Offloading mobile data traffic for QoS-aware service provision in vehicular cyber-physical systems[J]. Future Generation Computer Systems, 2016, 61: 118-127.
- [119] JINDAL A, AUJLA G S, KUMAR N, et al. SeDaTiVe: SDN-enabled deep learning architecture for network traffic control in vehicular cyber-physical systems[J]. IEEE Network, 2018, 32(6): 66-73.
- [120] ZHU H, ZHOU Y, LUO X, et al. Joint control of power, beamwidth, and spacing for platoon-based vehicular cyber-physical systems[J]. IEEE Transactions on Vehicular Technology, 2022, 71(8): 8615-8629.
- [121] WANG S, CHEN G, JIANG Y, et al. A cluster-based V2V approach for mixed data dissemination in urban scenario of IoVs[J]. IEEE Transactions on Vehicular Technology, 2023, 72(3): 2907-2920.
- [122] CHEN Y, WANG Y, ZHANG J, et al. QoS-driven spectrum sharing for reconfigurable intelligent surfaces (RISs) aided vehicular networks[J]. IEEE Transactions on Wireless Communications, 2021, 20(9): 5969-5985.
- [123] LAI C F, CHANG Y C, CHAO H C, et al. A buffer-aware QoS streaming approach for SDN-enabled 5G vehicular networks[J]. IEEE Communications Magazine, 2017, 55(8): 68-73.

- [124] TIAN J, LIU Q, ZHANG H, et al. Multiagent deep-reinforcement-learning-based resource allocation for heterogeneous QoS guarantees for vehicular networks[J]. IEEE Internet of Things Journal, 2022, 9(3): 1683-1695.
- [125] ZHANG S, LUO H, LI J, et al. Hierarchical soft slicing to meet multi-dimensional QoS demand in cache-enabled vehicular networks[J]. IEEE Transactions on Wireless Communications, 2020, 19(3): 2150-2162.
- [126] SODHRO A H, SODHRO G H, GUIZANI M, et al. AI-enabled reliable channel modeling architecture for fog computing vehicular networks[J]. IEEE Wireless Communications, 2020, 27(2): 14-21.
- [127] ZHAO L, YANG K, TAN Z, et al. A novel cost optimization strategy for SDN-enabled UAV-assisted vehicular computation offloading[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 22(6): 3664-3674.
- [128] ZHANG H, ZHANG Q, MA L, et al. A hybrid ant colony optimization algorithm for a multiobjective vehicle routing problem with flexible time windows[J]. Information Sciences, 2019, 490: 166-190.
- [129] NING Z, DONG P, WANG X, et al. When deep reinforcement learning meets 5G-enabled vehicular networks: A distributed offloading framework for traffic big data[J]. IEEE Transactions on Industrial Informatics, 2020, 16(2): 1352-1361.
- [130] TAN L T, HU R Q, HANZO L. Twin-timescale artificial intelligence aided mobility-aware edge caching and computing in vehicular networks[J]. IEEE Transactions on Vehicular Technology, 2019, 68(4): 3086-3099.
- [131] HUI Y, MA X, SU Z, et al. Collaboration as a service: Digital-twin-enabled collaborative and distributed autonomous driving[J]. IEEE Internet of Things Journal, 2022, 9(19): 18607-18619.
- [132] MUGABARIGIRA B A, SHEN Y, JEONG J, et al. Context-aware navigation protocol for safe driving in vehicular cyber-physical systems[J]. IEEE Transactions on Intelligent Transportation Systems, 2023, 24(1): 128-138.
- [133] CHANG W J, CHEN L B, CHIOU Y Z. Design and implementation of a drowsiness-fatigue-detection system based on wearable smart glasses to increase road safety[J]. IEEE Transactions on Consumer Electronics, 2018, 64(4): 461-469.
- [134] DUTTA R G, HU Y, YU F, et al. Design and analysis of secure distributed estimator for vehicular platooning in adversarial environment[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(4): 3418-3429.
- [135] WANG S H, HSIA S C, ZHENG M J. Deep learning-based raindrop quantity detection for real-time vehicle-safety application[J]. IEEE Transactions on Consumer Electronics, 2021, 67 (4): 266-274.
- [136] SUN Y E, HUANG H, YANG W, et al. Toward differential privacy for traffic measurement in vehicular cyber-physical systems[J]. IEEE Transactions on Industrial Informatics, 2022, 18(6): 4078-4087.

- [137] ZHANG T, ZOU Y, ZHANG X, et al. Data-driven based cruise control of connected and automated vehicles under cyber-physical system framework[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 22(10): 6307-6319.
- [138] ZHAO Y, LIU Z, WONG W S. Resilient platoon control of vehicular cyber physical systems under DoS attacks and multiple disturbances[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(8): 10945-10956.
- [139] PAN D, DING D, GE X, et al. Privacy-preserving platooning control of vehicular cyber–physical systems with saturated inputs[J]. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 2023, 53(4): 2083-2097.
- [140] LI K, NI W, ZHENG J, et al. Confidentiality and timeliness of data dissemination in platoon-based vehicular cyber-physical systems[J]. IEEE Network, 2021, 35(4): 248-254.
- [141] KAMAL M A S, TAN C P, HAYAKAWA T, et al. Control of vehicular traffic at an intersection using a cyber-physical multiagent framework[J]. IEEE Transactions on Industrial Informatics, 2021, 17(9): 6230-6240.
- [142] SONG W, YANG Y, FU M, et al. Real-time obstacles detection and status classification for collision warning in a vehicle active safety system[J]. IEEE Transactions on Intelligent Transportation Systems, 2018, 19(3): 758-773.
- [143] WU K H, LIN D B, WANG C W, et al. Series feed broadband patch array antenna design for vehicle collision warning radar system[C]//Proceedings of Joint International Symposium on Electromagnetic Compatibility, Sapporo and Asia-Pacific International Symposium on Electromagnetic Compatibility (EMC Sapporo/APEMC). Tokyo: IEEE, 2019: 490-493.
- [144] WANG X, TANG J, NIU J, et al. Vision-based two-step brake detection method for vehicle collision avoidance[J]. Neurocomputing, 2016, 173: 450-461.
- [145] SONG W, YANG Y, FU M, et al. Lane detection and classification for forward collision warning system based on stereo vision[J]. IEEE Sensors Journal, 2018, 18(12): 5151-5163.
- [146] HAFNER M R, CUNNINGHAM D, CAMINITI L, et al. Cooperative collision avoidance at intersections: Algorithms and experiments[J]. IEEE Transactions on Intelligent Transportation Systems, 2013, 14(3): 1162-1175.
- [147] GELBAL S Y, ARSLAN S, WANG H, et al. Elastic band based pedestrian collision avoidance using V2X communication[C]//Proceedings of IEEE Intelligent Vehicles Symposium (IV). Redondo Beach, California: IEEE, 2017: 270-276.
- [148] 李可欣, 王兴伟, 易波, 等. 智能软件定义网络[J]. 软件学报, 2021, 32(1): 118-136.
- [149] LIU S, YU J, DENG X, et al. FedCPF: An efficient-communication federated learning approach for vehicular edge computing in 6G communication networks[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(2): 1616-1629.
- [150] SINGH A, AUJLA G S, BALI R S. Intent-based network for data dissemination in software-defined vehicular edge computing[J]. IEEE Transactions on Intelligent Transportation Systems, 2020, 22(8): 5310-5318.

- [151] DAI Y, XU D, ZHANG K, et al. Deep reinforcement learning and permissioned blockchain for content caching in vehicular edge computing and networks[J]. IEEE Transactions on Vehicular Technology, 2020, 69(4): 4312-4324.
- [152] SU Z, HUI Y, XU Q, et al. An edge caching scheme to distribute content in vehicular networks [J]. IEEE Transactions on Vehicular Technology, 2018, 67(6): 5346-5356.
- [153] ZHANG Y, CHU L, OU Y, et al. A cyber-physical system-based velocity-profile prediction method and case study of application in plug-in hybrid electric vehicle[J]. IEEE Transactions on Cybernetics, 2019, 51(1): 40-51.
- [154] KUMAR A S, ZHAO L, FERNANDO X. Multi-agent deep reinforcement learning-empowered channel allocation in vehicular networks[J]. IEEE Transactions on Vehicular Technology, 2022, 71(2): 1726-1736.
- [155] 王桂芝, 吕光宏, 贾吾财, 等. 机器学习在 SDN 路由优化中的应用研究综述[J]. 计算机研究与发展, 2020, 57(4): 688-698.
- [156] JAIN R, PAUL S. Network virtualization and software defined networking for cloud computing: A survey[J]. IEEE Communications Magazine, 2013, 51(11): 24-31.
- [157] SHI W, CAO J, ZHANG Q, et al. Edge computing: Vision and challenges[J]. IEEE Internet of Things Journal, 2016, 3(5): 637-646.
- [158] 李智勇, 王琦, 陈一凡, 等. 车辆边缘计算环境下任务卸载研究综述[J]. 计算机学报, 2021, 44(5): 963-982.
- [159] 祖家琛, 胡谷雨, 严佳洁, 等. 网络功能虚拟化下服务功能链的资源管理研究综述[J]. 计算机研究与发展, 2021, 58(1): 137-152.
- [160] QIAN Z, WU F, PAN J, et al. Minimizing age of information in multi-channel time-sensitive information update systems[C]//Proceedings of IEEE International Conference on Computer Communications (INFOCOM). Virtual Conference: IEEE, 2020: 446-455.
- [161] TAKINE T. Queue length distribution in a FIFO single-server queue with multiple arrival streams having different service time distributions[J]. Queueing System, 2001, 39(4): 349-375.
- [162] SADEK A K, HAN Z, LIU K R. Distributed relay-assignment protocols for coverage expansion in cooperative wireless networks[J]. IEEE Transactions on Mobile Computing, 2009, 9(4): 505-515.
- [163] TANDRA R, SAHAI A. SNR walls for signal detection[J]. IEEE Journal of Selected Topics in Signal Processing, 2008, 2(1): 4-17.
- [164] 刘浩洋, 户将, 李勇锋, 等. 最优化: 建模、算法与理论[M]. 北京: 高等教育出版社, 2020.
- [165] FOERSTER J N, FARQUHAR G, AFOURAS T, et al. Counterfactual multi-agent policy gradients[C]//Proceedings of AAAI Conference on Artificial Intelligence (AAAI). New Orleans, Louisiana: AAAI, 2018: 2974-2982.
- [166] HOFMANN T. Unsupervised learning by probabilistic latent semantic analysis[J]. Machine Learning, 2001, 42(1): 177-196.

- [167] WANG J, LIU K, LI B, et al. Delay-sensitive multi-period computation offloading with reliability guarantees in fog networks[J]. IEEE Transactions on Mobile Computing, 2019, 19(9): 2062-2075.
- [168] BAGHERI H, NOOR-A-RAHIM M, LIU Z, et al. 5G NR-V2X: Toward connected and cooperative autonomous driving[J]. IEEE Communications Standards Magazine, 2021, 5(1): 48-54.
- [169] ISLAM S M R, AVAZOV N, DOBRE O A, et al. Power-domain non-orthogonal multiple access (NOMA) in 5G systems: Potentials and challenges[J]. IEEE Communications Surveys & Tutorials, 2017, 19(2): 721-742.
- [170] ZHENG L, FIEZ T, ALUMBAUGH Z, et al. Stackelberg actor-critic: Game-theoretic reinforcement learning algorithms[C]//Proceedings of AAAI Conference on Artificial Intelligence (AAAI). Virtual Conference: AAAI, 2022: 9217-9224.
- [171] RAJESWARAN A, MORDATCH I, KUMAR V. A game theoretic framework for model based reinforcement learning[C]//Proceedings of International Conference on Machine Learning (ICML). Virtual Conference: PMLR, 2020: 7953-7963.
- [172] Lã Q D, CHEW Y H, SOONG B H. Potential game theory[M]. Cham, Switzerland: Springer Cham, 2016.
- [173] BARTH-MARON G, HOFFMAN M W, BUDDEN D, et al. Distributed distributional deterministic policy gradients[C]//Proceedings of International Conference on Learning Representations (ICLR). Vancouver, Canada: Open Publishing, 2018.
- [174] KHAN W U, LIX, IHSAN A, et al. NOMA-enabled optimization framework for next-generation small-cell IoV networks under imperfect SIC decoding[J]. IEEE Transactions on Intelligent Transportation Systems, 2021, 23(11): 22442-22451.
- [175] SUN Y, DING Z, DAI X, et al. Performance of downlink NOMA in vehicular communication networks: An analysis based on Poisson line cox point process[J]. IEEE Transactions on Vehicular Technology, 2020, 69(11): 14001-14006.
- [176] 杜剑波, 薛哪哪, 孙艳, 等. 基于 NOMA 的车辆边缘计算网络优化策略[J]. 物联网学报, 2021, 5(1): 19-26.
- [177] CORMEN T H, LEISERSON C E, RIVEST R L, et al. Introduction to algorithms[M]. Cambridge, Massachusetts: MIT Press, 2022.
- [178] PAPANDRIOPOULOS J, EVANS J S. Low-complexity distributed algorithms for spectrum balancing in multi-user DSL networks[C]//Proceedings of IEEE International Conference on Communications (ICC). Istanbul, Turkey: IEEE, 2006: 3270-3275.
- [179] BOYD S, BOYD S P, VANDENBERGHE L. Convex optimization[M]. Cambridge, England: Cambridge University Press, 2004.
- [180] ZHOU Z, LIU P, FENG J, et al. Computation resource allocation and task assignment optimization in vehicular fog computing: A contract-matching approach[J]. IEEE Transactions on Vehicular Technology, 2019, 68(4): 3113-3125.
- [181] ZHU H, YUEN K V, MIHAYLOVA L, et al. Overview of environment perception for intelligent

- vehicles[J]. IEEE Transactions on Intelligent Transportation Systems, 2017, 18(10): 2584-2601.
- [182] ZHAO C, DAI X, LV Y, et al. Foundation models for transportation intelligence: ITS convergence in TransVerse[J]. IEEE Intelligent Systems, 2022, 37(6): 77-82.
- [183] IEPURE B, MORALES A W. A novel tracking algorithm using thermal and optical cameras fused with mmWave radar sensor data[J]. IEEE Transactions on Consumer Electronics, 2021, 67(4): 372-382.
- [184] CHANG W J, CHEN L B, SIE C Y, et al. An artificial intelligence edge computing-based assistive system for visually impaired pedestrian safety at zebra crossings[J]. IEEE Transactions on Consumer Electronics, 2021, 67(1): 3-11.
- [185] WI Y M, LEE J U, JOO S K. Electric vehicle charging method for smart homes/buildings with a photovoltaic system[J]. IEEE Transactions on Consumer Electronics, 2013, 59(2): 323-328.
- [186] BAI Z, HAO P, SHANGGUAN W, et al. Hybrid reinforcement learning-based eco-driving strategy for connected and automated vehicles at signalized intersections[J]. IEEE Transactions on Intelligent Transportation Systems, 2022, 23(9): 15850-15863.
- [187] HADJIGEORGIOU A, TIMOTHEOU S. Real-time optimization of fuel-consumption and travel-time of CAVs for cooperative intersection crossing[J]. IEEE Transactions on Intelligent Vehicles, 2023, 8(1): 313-329.
- [188] WANG Y, CHEN Y, LI G, et al. City-scale holographic traffic flow data based on vehicular trajectory resampling[J]. Scientific Data, 2023, 10(1): 57.
- [189] MOLTAFET M, LEINONEN M, CODREANU M. On the age of information in multi-source queueing models[J]. IEEE Transactions on Communications, 2020, 68(8): 5003-5017.
- [190] LIU K, LIM H B, FRAZZOLI E, et al. Improving positioning accuracy using GPS pseudorange measurements for cooperative vehicular localization[J]. IEEE Transactions on Vehicular Technology, 2013, 63(6): 2544-2556.
- [191] KENNEY J B. Dedicated short-range communications (DSRC) standards in the United States [J]. Proceedings of the IEEE, 2011, 99(7): 1162-1182.
- [192] SAMORADNITSKY G. Stable non-gaussian random processes: Stochastic models with infinite variance[M]. London: Routledge, 2017.
- [193] FAMA E F, ROLL R. Parameter estimates for symmetric stable distributions[J]. Journal of the American Statistical Association, 1971, 66(334): 331-338.
- [194] KOUTROUVELIS I A. Regression-type estimation of the parameters of stable laws[J]. Journal of the American Statistical Association, 1980, 75(372): 918-928.
- [195] VOGEL K. A comparison of headway and time to collision as safety indicators[J]. Accident Analysis & Prevention, 2003, 35(3): 427-433.
- [196] UPPOOR S, TRULLOLS-CRUCES O, FIORE M, et al. Generation and analysis of a large-scale urban vehicular mobility dataset[J]. IEEE Transactions on Mobile Computing, 2013, 13 (5): 1061-1075.