Vehicle Computing

Zheng Dong, Wayne State University, Detroit, MI, 48202, USA
Weisong Shi, University of Delaware, Newark, DE, 19716, USA

Given the ongoing trajectory of advancements in communications, semiconductors, and the automotive industry, it's plausible to anticipate that the next noteworthy leap in the realm of mobile computing might center around the concept of vehicle computing (VC). VC pertains to the innovative technologies that enable computational processes to take place within intelligent connected vehicles. However, due to the lack of comprehensive research that bridges various interdisciplinary domains, this new era of VC also introduces intricate interactions among traditionally distinct research areas, which have historically developed in parallel. The projected significant impacts and the inherently multidisciplinary nature of VC underscore the necessity for focused attention and consideration from researchers, industries, governments, and pertinent professional communities. With this in mind, the primary objective of this special issue is to present cutting-edge contributions and outline future trajectories from experts across diverse domains and fields within the realm of VC.

Over the past century, vehicles have primarily functioned as modes of transportation. However, with the rapid integration of onboard sensing, computing, communication, storage, and battery capabilities, a compelling vision emerges. We anticipate that in the forthcoming century, intelligent connected vehicles (ICVs) will transcend their traditional transportation role and evolve into dynamic mobile internet computing platforms. This transformation will empower them to not only facilitate conventional travel but also to serve as pivotal hubs for a myriad of next-generation services. These services encompass a wide spectrum, including mobility-as-a-service, optimization of fuel efficiency, and the generation of high-definition (HD) maps, among others. Anchoring these services are software-driven capabilities that fuel the ICV market. Notably, the Automotive Edge Computing Consortium (AECC) projects a momentous shift, with up to 400 million new vehicles anticipated to be connected by 2025. This projection foreshadows a future where an impressive 50% of national vehicles on the road will be endowed with connected features, reshaping the landscape of vehicular technology, especially vehicle computing.

The goal of this special issue is to gather pioneering contributions that not only showcase the forefront of advancements but also chart the forthcoming trajectories within the expansive domain of VC. The compilation of three featured articles encapsulates an array of novel technologies, visionary insights, and ambitious projects within the realm of VC.

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The first article, "A Zero-Trust Architecture for Connected and Autonomous Vehicles,"[A1] discusses the security challenges surrounding connected and autonomous vehicles (CAVs), focusing on securing the controller area network (CAN) bus technology used in internal vehicle networks (IVNs). The aim is to protect the components of a CAV's sensor and control network using a zero trust architecture (ZTA). The ZTA involves components like policy enforcement points, policy decision points, policy engine, policy administrator, context manager, and device fingerprinting, all working together to ensure continuous system integrity verification. The article emphasizes the need for stringent security measures as CAVs become more prevalent, and highlights specific threats like CAN bus attachment, injection attacks, spoofing, and segmentation attacks. The proposed ZTA aims to safeguard CAV operations and protect against these vulnerabilities.

The second article, "Multiagent Federated Deep-Reinforcement-Learning-Enabled Resource Allocation for an Air–Ground-Integrated Internet of Vehicles Network,"[A2] introduces the concept of an air-ground integration network for the future 6G Internet of vehicles (IoV), utilizing unmanned aerial vehicles (UAVs) alongside ground infrastructures. Challenges in wireless resource allocation for vehicle-to-UAV (V2U) communications are highlighted, including spectrum sharing, dynamic topology, and time-sensitive services. The article proposes a resource allocation strategy called Fed-D3QN, combining multi-agent federated learning and dueling double deep Q network (D3QN) to optimize channel selection and power control. The approach is validated through simulations, demonstrating its stability and efficiency in improving communication performance within the dynamic air–ground integration network of IoV.

The third article, "EQuaTE: Efficient Quantum Train Engine for Runtime Dynamic Analysis and Visual Feedback in Autonomous Driving,"[A3] proposes an efficient quantum train engine (EQuaTE) designed for quantum neural network (QNN) autonomous driving software. EQuaTE aims to confirm the occurrence of barren plateaus, and local minima situations in QNN, by plotting gradient variances, thus enabling real-time testing and stability assessment during autonomous driving operations. The dynamic analysis is necessary due to undetermined probabilistic qubit states during runtime. EQuaTE's visual feedback mechanism identifies barren plateaus on local autonomous driving platforms and visualizes this information on a remotely connected cloud. The cloud subsequently reorganizes and retrains the QNN stored on it to eliminate barren plateaus, enhancing QNN performance. This article addresses feasibility concerns in QNN software development tools, aiming to improve the efficiency and effectiveness of QNN applications in autonomous driving.

The articles showcased in this special issue offer initial research perspectives on VC, yet they only scratch the surface of the imminent VC era. With an eye toward a more exhaustive exploration of VC's capabilities, we eagerly anticipate upcoming research that will illuminate its advantages in the realm of next-generation mobile computing. The insights shared in this special issue are positioned to catalyze subsequent progress and unveil new revelations in the coming times.

APPENDIX: RELATED ARTICLES

A1. J. Anderson, Q. Huang, L. Cheng, and H. Hu, "A zero-trust architecture for connected and autonomous vehicles," *IEEE Internet Comput.*, vol. 27, no. 5, pp. 7–14, Sep./Oct. 2023, doi: 10.1109/MIC.2023.3304893.

A2. N. Li, X. Song, K. Li, R. Jiang, and J. Li, "Multiagent federated deep-reinforcement-learning-enabled resource allocation for an air–Ground-integrated internet of vehicles network," *IEEE Internet Comput.*, vol. 27, no. 5, pp. 15–23, Sep./Oct. 2023, doi: 10.1109/MIC.2023.3307431.

A3. S. Park, H. Feng, C. Park, Y. K. Lee, S. Jung, and J. Kim, "EQuaTE: Efficient quantum train engine for runtime dynamic analysis and visual feedback in autonomous driving," *IEEE Internet Comput.*, vol. 27, no. 5, pp. 24–31, Sep./Oct. 2023, doi: 10.1109/MIC.2023.3307395.

ZHENG DONG is an assistant professor in the Department of Computer Science, Wayne State University, Detroit, MI, 48202, USA. Contact him at dong@wayne.edu.

WEISONG SHI is a professor and chair in the Department of Computer and Information Sciences, University of Delaware, Newark, DE, 19716, USA. Contact him at weisong@udel.edu.