Guest Editorial >>>

Special Topic on Evolution of AI Enabled Wireless Networks

Guest Editors

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Evolving to 6G wireless communications, "Internet connecting things" is becoming "Internet connecting intelligence". In order to adapt to this trend, wireless devices should be capable of conducting efficient and robust communications and also complete complex services of smart applications. However, the current wireless networks are trapped in delivering a massive number of signals while assuring their accuracy, and the limited resources block this evolution. The big data technology is a persistently-developing paradigm, which facilitates the change of network functions from "transmit every bit" to "what and how to transmit". In particular, artificial intelligence (AI) technologies allow intelligent devices to pre-process information according to environment and service's demands. Additionally, forwarding critical information in a more efficient and accurate way may support complicated AI tasks such as virtual reality, augmented reality, and autonomous driving. However, there still exist many fundamental research challenges, such as high quality wireless connectivity as well as high accuracy and robust sensing capability, which need to be solved for accommodating AI techniques towards 6G wireless communications.

In this special issue, a series of articles are presented to propose innovative solutions to enabling AI techniques over wireless networks. These papers cover a wide range of topics, including 6G wireless communication protocols, semantic communications, green energy efficiency concerns, network architecture designs, and the application of AI techniques in future wireless networks. The call-for-papers of this special issue have brought excellent submissions in both quality and quantity. After two-round reviews, ten excellent papers have been selected for publication in this special issue which is organized as follows.

The first paper titled "Intelligent 6G Wireless Network with Multi-Dimensional Information Perception" focuses on the critical issues and proposes three application scenarios in 6G wireless systems. The intelligent wireless network and information perception require a deep fusion of AI and wireless communications in 6G systems. Therefore, the fusion of AI and 6G networks is discussed for the enhancement of 5G-advanced technologies and future wireless communication systems. The wireless AI technology architecture with 6G multi-dimensional information perception is then introduced.

The second paper titled "Deep Learning-Based Semantic Feature Extraction: A Literature Review and Future Directions" provides an overview of the applications of semantic feature extraction in various fields, aiming to provide insights into the potential of this technology to advance the development of artificial intelligence. The applications of semantic feature extraction in natural language processing, hyperspectral image analysis, disease diagnosis and medical image analysis, and autonomous driving are focused. The development trends and challenges are also explored.

The third paper titled "Content Popularity Prediction via Federated Learning in Cache-Enabled Wireless Networks" proposes a privacy-preserving algorithm based on federated learning (FL) and long short-term memory (LSTM), which is referred to as FL-LSTM, to predict content popularity and reduce the risk of privacy leakage. The performance of the proposed FL-LSTM is close to the centralized LSTM and better than other benchmark algorithms in terms of privacy protection. Meanwhile, the caching policy in this paper raises about 14.3% of the content bit rate.

The fourth paper titled "Federated Learning for 6G: A Survey from Perspective of Integrated Sensing, Communication and Computation" contributes to the understanding of FL in the context of wireless networks and provides insights into addressing the challenges and optimizing the design for the integration of FL into future 6G networks. This paper provides a

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comprehensive survey of FL, with special emphasis on the design and optimization of integrated sensing, communication and computation (ISCC). Subsequently, the challenges are highlighted and the state of the art in potential solutions is reviewed. Design guidelines are also provided for the incorporation of FL and ISCC.

The fifth paper titled "Future Vision on Artificial Intelligence Assisted Green Energy Efficiency Network" proposes AI/machine learning (ML)-assisted energy-saving strategies to achieve optimal performance in terms of cell shutdown duration and energy efficiency. 5G new radio is designed to enable denser network deployments, which raises significant concerns about network energy consumption. The AI/ML based energy saving schemes achieve great performance on power consumption and energy efficiency. Moreover, further consideration on future wireless communication networks is put forward.

The sixth paper titled "Machine Learning Driven Latency Optimization for Internet of Things Applications in Edge Computing" introduces a machine learning-enabled orchestration framework, which utilizes the states of edge resources and application resource requirements to facilitate a resource-aware offloading scheme for minimizing the average latency of emerging Internet-of-Things applications. Moreover, a variant bin-packing optimization model is further proposed, which colocates applications firmly on edge resources to fully utilize available resources.

The seventh paper titled "Multi-User MmWave Beam Tracking via Multi-Agent Deep Q-Learning" proposes a multi-user beam tracking algorithm by using a distributed deep Q-learning method to reduce overhead cost. By online learning of users' moving trajectories, the proposed algorithm learns to scan a beam subspace, aiming to maximize the average effective sum-rate. Considering practical implementation, the continuous beam tracking problem is considered as a non-Markov decision process and a simplified training scheme of deep Q-learning with low complexity is developed. Furthermore, a scalable state-action-reward is designed for scenarios with different users and antenna numbers.

The eighth paper titled "RIS-Assisted UAV-D2D Communications Exploiting Deep Reinforcement Learning" proposes a reconfigurable intelligent surface (RIS) model to rebuild the wireless channels for mitigating the strong interference caused by line-of-sight (LoS) air-to-ground channels in a device-to-device (D2D) communication system underlying cellular networks enabled by unmanned aerial vehicle (UAV). A RIS softmax deep double deterministic (RIS-SD3) policy gradient method is also proposed, which could smooth the optimization space as well as reduce the number of local optimizations.

The ninth paper titled "SST-V: A Scalable Semantic Transmission Framework for Video" provides a highly-efficient solution to video transmission by proposing a scalable semantic transmission algorithm, named scalable semantic transmission framework for video (SST-V), which jointly considers the semantic importance and channel conditions. Specifically, a semantic importance evaluation module is designed to extract more informative semantic features according to the estimated importance level, facilitating high-efficiency semantic coding. By further considering the channel condition, a cascaded learning based scalable joint semantic-channel coding algorithm is proposed, which autonomously adapts the semantic coding and channel coding strategies to the specific signal-to-noise ratio (SNR).

The last paper titled "UAV Autonomous Navigation for Wireless Powered Data Collection with Onboard Deep Q-Network" proposes to jointly optimize the UAV's flight trajectory, the sensor selection and operation modes in order to maximize the average data traffic of all sensors within a wireless sensor network (WSN) during finite UAV's flight time, while ensuring the energy required for each sensor by wireless power transfer (WPT). For the sake of considering a practical scenario, the UAV has no prior knowledge of sensor locations. Therefore, the deep Q-network (DQN) is employed to execute the navigation based on the UAV position, the battery level state, channel conditions and current data traffic of sensors within the UAV's coverage area.

To conclude, it is hoped that this special issue will serve as a valuable resource for researchers, practitioners, and students who are interested in AI techniques over wireless networks. We also hope that it will inspire further research in this field, leading to new and innovative solutions that will drive the evolution of AI techniques. Finally, we would like to express our sincere gratitude to all the authors, reviewers, and editorial staff who have contributed to the success of this special issue. Hopefully, the articles in this special issue are both insightful and informative for prospective readers in the field.

Biographies

WANG Ling received his BS, MS, and PhD degrees in electronic engineering from Xidian University, China in 1999, 2002 and 2004, respectively. From 2004 to 2007, he worked at Siemens and Nokia Siemens Networks. Since 2007, he has been with the School of Electronic and Information, Northwestern Polytechnical University, China, and was promoted to Professor in 2012. His current research interests include array processing and smart antennas, wideband communications, cognitive radio, adaptive anti-jamming for satellite communications, satellite navigation, and date link systems.

GAO Yin is a senior expert in wireless communication standardization and industrial relationship of ZTE Corporation and the 3GPP RAN3 Chair. She possesses 16 plus years of experience in the telecommunication industry and 14 plus years in the 3GPP RAN3 working group. She received her bachelor's and master's degrees from Xidian University, China. She joined ZTE and worked on software development and system design of the wireless communication system as early as 2005. Starting in 2007, she has been focusing on advanced radio access technology research and standardization with over 500 3GPP contributions and over 50 granted patents globally. She has been served as RAN3 Vice Chair of 3GPP RAN3 since 2017 and was elected as Chair of 3GPP RAN3 in May 2021.