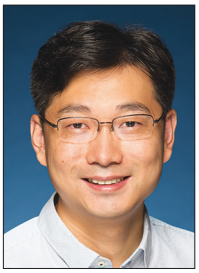
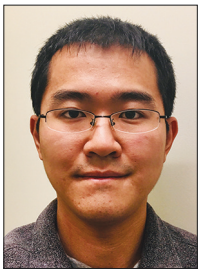
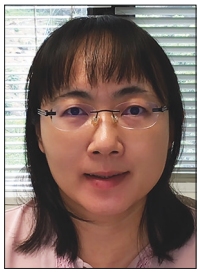
Interplay Between Machine Learning and Networking Systems

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In recent times, the progression of machine learning (ML) methodologies, particularly deep learning, reinforcement learning (RL), and federated learning (FL), has resulted in notable advancements across various application domains. The flourishing of ML is attributed to the development of the Internet, mobile networks, and the Internet of Things, which aid in generating and disseminating data. Concurrently, the networking community has experienced a rapidly increasing trend in employing ML to address complex issues in network design, management, and optimization, which have historically been approached through mathematical optimization theory or human-crafted heuristics.

Nevertheless, despite the extensive achievements of ML-related research within networking systems, several challenges persist. These include the absence of open datasets, open-source toolkits, and benchmark suites, as well as issues concerning the security and privacy, interpretability and resilience of ML models, and communication bottlenecks in distributed ML systems, among others. The aim of this Special Issue (SI) is to compile the latest research findings pertaining to machine learning technology and its applications in networking systems. Following the Call for Papers, we have garnered a total of 59 high-quality submissions from around the globe. After a rigorous review process, 13 outstanding papers have been selected for this SI, covering the following three major areas: (1) network management; (2) mobile and wireless networks.

Area 1: Network Management

In the article, "Bayesian Tensor Completion for Network Traffic Prediction," the authors present a new Bayesian tensor completion model to predict network traffic data. The proposed method aims to solve the problem of predicting missing network traffic data by representing them with a third-order tensor and using Bayesian tensor completion for low-rank decomposition.

In the next article, "Opportunities and Implementation of Neural Machine Translation in Network Configuration," the authors propose a general architecture of network configuration Neural Machine Translation model, and unsupervised configuration translation method to solve the problems existing in current network configuration translation.

In the article, "G-Routing: Graph Neural Networks-Based Flexible Online Routing," the authors propose a method called G-Routing that uses Graph Neural Network (GNN) and Deep Reinforcement Learning (DRL) to optimize routing in networking systems. The algorithm employs GNN to predict the evolution of network performance metrics in the future time period and assist DRL-based routing algorithm in selecting the optimal path.

In the article, "Learning-Based Network Performance Estimators: The Next Frontier for Network Simulations," the authors discuss the limitations of conventional rule-based network simulators in accurately predicting network performance in large-scale networks. The article further proposes the use of deep learning techniques to construct the next frontier of network performance estimators that can be both accurate and scalable.

Area 2: Mobile and Wireless Networks

The article, "Toward Reinforcement-Learning-Based Intelligent Network Control in 6G Networks," focuses on resource allocation and network management in 6G networks using RL. The article uses the smart grid as a case study to demonstrate the critical role of RL-based methods in capacitating intelligent power system management in 6G networks.

In the article, "Communication-Efficient and Byzantine-Robust Federated Learning for Mobile Edge Computing Networks," the authors address the challenges of using FL in mobile edge computing networks, including limited communication overhead, edge dynamics, data imbalance, and resource constraints. The article introduces a Byzantine-robust FL mechanism to ensure the security and reliability of the learning process.

In the next article, "Optimizing Efficient Personalized Federated Learning with Hypernetworks at Edge," the authors discuss the challenges and opportunities of implementing FL in large-scale IoT scenarios and propose an edge-based personalized FL approach called EdgeFHN, aiming to reduce communication costs while achieving higher inference accuracy.

In the article, "ENORA: Empowering Energy-Neutral Operation in LoRa Networks via Embedded Intelligence," the authors propose ENORA, a framework that leverages real-world solar-energy harvesting traces to investigate the impact of these energy-neutral factors and introduces a novel transmission-management framework that empowers energy-neutral operation in energy-harvesting LoRa networks via embedded intelligence.

In the article, "Task-Oriented Integrated Sensing, Computation and Communication for Wireless Edge AI," the authors discuss the integration of sensing, computation, and communication for edge learning and inference, specifically in the context of task-oriented integrated sensing, computation, and communication (ISCC) for wireless edge AI. The article covers enabling technologies of ISCC, human-motion recognition and multi-view sensing use cases of ISCC in task-oriented edge AI, and emerging ISCC solutions to combat challenges in the B5G edge AI tasks.

Area 3: Security and Privacy

In the article, "Byzantine-Resilient Online Federated Learning with Applications to Network Traffic Classification," the authors explore the problem of Byzantine attacks in online federated learning for network traffic classification. The authors propose a novel algorithm called BROFL (Byzantine-Resilient Online Fed-

erated Learning) to detect and mitigate the effects of Byzantine agents, while maintaining high accuracy and efficiency.

In the article, "FDSFL: Filtering Defense Strategies Toward Targeted Poisoning Attacks in IIoT-based Federated Learning Networking System," the authors present filtering defense strategies to mitigate the impact of these attacks and ensure the security and privacy of the data being used in the federated learning process.

In the article, "BC-MetaCast: A Blockchain-Enhanced Intelligent Computing Framework for Metaverse Livecast," the authors present a cutting-edge blockchain-enhanced intelligent computing framework for metaverse livecast. The proposed framework offers an efficient, decentralized, and truthful task assignment for live stream processing.

In the article, "Blockchain-Enabled Cross-Layer Radio Frequency Fingerprinting Identification with Machine Learning for IIoT," a blockchain-enabled cross-layer radio frequency fingerprinting (RFF) identification framework is proposed. It enhances security in the industrial Internet of Things (IIoT) by using physical layer authentication, machine learning, and blockchain technology.

In conclusion, the Guest Editor team extends its gratitude to all authors who contributed their original research endeavors to this SI, as well as the reviewers who offered prompt and insightful feedback. Furthermore, we express our appreciation to Dr. Chonggang Wang, the Editor-in-Chief, for his unwavering assistance and direction, and to the IEEE Network staff for their indispensable support throughout the preparation of the SI.

Biographies

Xiaowen Chu [SM] received his B.Eng. degree in Computer Science from Tsinghua University, Beijing, P. R. China, in 1999, and his Ph.D. degree in Computer Science from The Hong Kong University of Science and Technology in 2003. Since then, he has been with the Department of Computer Science, Hong Kong Baptist University. He is currently a Professor at the Data Science and Analytics Thrust, Information Hub of HKUST(GZ), and an affiliate Professor in the Department of Computer Science and Engineering, HKUST. His research interests include GPU computing, distributed machine learning, cloud computing, and wireless networks. He received the Best Paper Award of IEEE INFOCOM, in 2021.

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