

DATA SCIENCE AND ARTIFICIAL INTELLIGENCE FOR COMMUNICATIONS



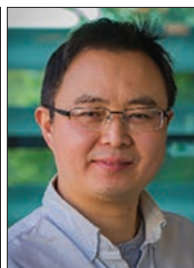
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Research in artificial intelligence (AI) has been active for several decades, but lately, and with the exponential increase in the amounts of available data, new directions of AI, such as machine learning (ML) and data analytics that learn from data, have emerged and have impacted many fields in science and engineering. This Series is dedicated to exploring these new trends, their latest developments, and their applications in the field of communications. This is the third issue of the Data Science and Artificial Intelligence for Communications Series, and the first in 2020. The Series has been steadily receiving many submissions which are reviewed by experts in the area in order to select the best papers for publication.

For this issue we selected six articles. These articles address the application of artificial intelligence, machine learning, and data analytics at different layers and different applications of different types of communications networks. The objective of using these tools is the optimal design and improved operation of networks. These articles feature new opportunities to develop and advance various areas of communications through the use and applications of AI/ML/deep learning technologies.

The first article, "Spectrum Intelligent Radio: Technology, Development, and Future Trends," is authored by P. Cheng, Z. Chen, M. Ding, Y. Li, B. Vucetic, and D. Niyato, and deals with machine learning applications at the physical layer in wireless networks. The article addresses the significant spectrum strains imposed by information collection and decision making in Industry 4.0, which is also known as the fourth industrial revolution. The article focuses on machine-learning-based intelligent radios as a viable solution to this problem and proposes a new radio architecture consisting of three hierarchical forms: perception, understanding, and reasoning. The purpose of these three forms is accurate spectrum sensing, accurate prediction of primary users' coverage, and optimal idle channel selection. The challenges and opportunities introduced by this framework are discussed.

The second article, "Toward an Intelligent Edge: Wireless Communication Meets Machine Learning" by G. Zhu, D. Liu, Y. Du, C. You, J. Zhang, and K. Huang, also deals with wireless networks in an environment with massive numbers of edge devices that collect data and upload this data to edge servers that learn from the data and distill intelligent decisions. Examples of such scenarios include sensors in IoT networks, auto-driving cars, and so on. The article proposes

a framework that includes a set of new design guidelines for wireless communications in edge learning, which is referred to as learning-driven communication. The article discusses research directions emerging under this framework and provides illustrative examples that cover key communication aspects including multiple access, resource allocation, and signal encoding.

The third article, "Programmable Multilayer INT: An Enabler for AI-assisted Network Automation," by S. Tang, J. Kong, B. Niu, and Z. Zhu, addresses traffic monitoring over optical networks. Advances in optical networks have increased the complexity of traffic monitoring, and the article proposes a programmable multilayer in-band network telemetry system, which can visualize a packet-over-optical network in real time, hence enabling performance monitoring and troubleshooting. This system applies artificial intelligence for the accurate identification and classification of root causes of exceptions in packet-over-optical networks in a timely manner.

The fourth article, "Evolving Switch Architecture toward Accommodating In-Network Intelligence," by S. Chen, X. Chen, Z. Yao, J. Yang, Y. Li, and F. Wu, proposes to replace traditional dumb switches, which only implement the forwarding function, with intelligent switches. Switches are therefore augmented with an intelligence plane which, together with the data and control planes, implements a sensing-cognizing-acting closed loop to understand and react automatically to the potential network events and dynamics. The authors implement the intelligence plane as a pluggable module consisting of an integrated solution of "X86 CPU+GPU+DPDK," and demonstrate potential applications for this intelligent switch, including in-network application identification and in-network anomaly detection.

The fifth article, "Machine Fault Detection for Intelligent Self-Driving Networks," by H. Huang, L. Zhao, H. Huang, and S. Guo, deals with self-driving networks (SelfDNs), which are autonomous networks that are capable of making predictive and adaptive responses to their environment. The article focuses on fault detection in SelfDNs, and proposes a new fault detection architecture for SelfDNs. Under this architecture, an algorithm, named Gaussian Bernoulli restricted Boltzmann machines (GBRBM)-based deep neural network with autoencoder (i.e., GBRBM-DAE), is proposed with the objective of transforming the fault detection problem into a classification problem. Several classification mechanisms

are considered and compared using traces from real-world experimental results, and it is shown that the proposed algorithm outperforms other popular machine learning algorithms, such as linear discriminant analysis, support vector machine, and pure deep neural network.

The collection of training data is difficult, especially if the amount of needed data is massive and the data is diverse, such as the sensitive data needed for applications that include facial recognition, natural language processing, and medical image processing. Collaborative learning addresses this issue by allowing participants to train a global model by uploading subsets of parameter changes to a centralized server instead of centralized data collection. This approach can leak private data if the involved entities are not trusted. The sixth and last article in this issue, "SecCL: Securing Collaborative Learning Systems via Trusted Bulletin Boards," which is co-authored by Z. Zhang, K. Xu, Q. Li, X. Liu, L. Li, B. Wu, and Y. Guo, addresses this issue. This article proposes a secure collaborative learning system called SecCL. SecCL provides strong privacy protection in collaborative learning, and this is done by ensuring authentic and correct message interaction. SecCL uses a trusted bulletin board (TBB) built upon blockchain. Moreover, a smart contract for SecCL is developed in order to allow participants to achieve consensus to restrain malicious behaviors. Therefore, servers and participants cannot behave in a deceptive manner. The authors also implement a prototype to evaluate the performance of SecCL, and show

that SecCL can throttle malicious behaviors, and can also guarantee the accuracy of the global model.

BIOGRAPHIES

IRENA ATOV [SM] (i.atov@ieee.org) received her Ph.D. in electrical engineering from RMIT University, Australia in 2003. She is currently Principal Architect at Microsoft, USA, in their Intelligent Conversation and Communications Cloud (IC3) Group, O365 Services. Previously, she has worked in academia, consulted for industry through her own company and worked for Telstra in Melbourne, Australia as Program Director of Network Analytics and Resilience. Her research in network architecture design and performance optimization led to the development of several commercial IT software products.

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