Artificial Intelligence and Data Science for Communications




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Welcome to the October issue of the Artificial Intelligence and Data Science for Communications Series of *IEEE Communications Magazine*. In this edition, we explore the transformative potential of machine learning (ML) and data science in network management, design, and optimization. Four compelling articles take center stage, illuminating the challenges and opportunities in this dynamic field.

The first article "Model Drift in Dynamic Networks" by Dimitrios Michael Manias, Ali Chouman, and Abdallah Shami addresses the critical issue of model drift in dynamic network environments. Motivated by the increasing reliance on ML models in evolving networks, the article highlights the potential risks and consequences of model drift on decision making and system performance degradation. The authors provide a comprehensive exploration of various types of model drift, point out the challenges associated with drift detection, classification, and mitigation, and introduce a novel drift detection and adaptation framework, exemplified through a case study simulating changing user behavior in a 5G network prototype. Results from the case study demonstrate the framework's efficacy in reducing threshold violations and improving system performance in the presence of concept drift. Overall, this work provides a robust foundation for combating model drift challenges in dynamic networks, offering insights into real-world applications and the integration of advanced intelligence techniques.

The second article, "Machine Learning for Robust Network Design: A New Perspective," by Chenyi Liu, Vaneet Aggarwal, Tian Lan, Nan Geng, Yuan Yang, and Mingwei Xu proposes a novel approach, employing machine learning to enhance robust network design by evaluating failure impacts efficiently and identifying critical scenarios. Instead of computationally heavy model-based optimization, the article proposes a graph attention network (GAT) to predict failure impacts efficiently. The proposed GAT-based model efficiently captures network features, utilizing both local and global attention mechanisms to comprehend the influence of neighboring nodes and global network states on failure impacts. Their method is tested on both synthetic and real-world topologies, demonstrating impressive efficiency gains while maintaining solution accuracy. Overall, this article showcases the potential of integrating ML into network engineering, potentially revolutionizing the way we approach network robustness.

The third article "Next Generation Mobile Networks' Enablers: Machine Learning-Assisted Mobility, Traffic, and Radio Channel Prediction" by Henrik Rydén, Hamed Farhadi, Alex Palaios, László Hévizi, David Sandberg, and Tor Kvernvik delves into the growing significance of ML in optimizing and automating radio access networks (RANs). The study highlights three core intelligence enablers: traffic prediction, radio channel prediction, and mobility prediction, and envisions scenarios like AI-enabled energy transfer for zero-energy devices, leveraging predictions to optimize energy harvesting and transmission. Furthermore, the concept of efficient programmable devices is introduced, wherein ML models are tailored to specific environments to enhance adaptability and network performance. Overall, the article underscores the pivotal role of ML in augmenting RANs and cellular networks. As cellular networks progress towards 6G, the intelligence enablers are poised to play a central role in shaping emerging use cases and improving overall system efficiency.

Slicing-enabled communication networks (SeCNs) hold significant importance in the realm of modern networking. The fourth article "Digital Twin for Optimization of Slicing-enabled Communication Networks: A Federated Graph Learning Approach" by Mohamed Abdel-Bassetl, Hossam Hawash, Karam M. Sallam, Ibrahim Elgendi, and Kumudu Munasinghe introduces a framework called FED-DT, designed to optimize resource allocation in SeCNs using federated graph intelligence. The framework utilizes a Graph Linformer Network (GLN) to learn complex network relationships and predict slice-level QoS metrics and Gaussian Differential Privacy (DP) for privacy preservation. The federated approach enables collaboration among network operators to train a global model without sharing sensitive data. Overall, the article addresses a pertinent challenge in SeCNs. The presented FED-DT framework seems to have the potential to significantly enhance the management and performance of SeCNs.

Our appreciation goes out to the authors and reviewers who have enriched the Series with their invaluable contributions. Furthermore, we extend our sincere gratitude to Dr. Antonio Sanchez-Esguevillas, the Editor-in-Chief of *IEEE Communications Magazine*, and Dr. Alberto Perotti, the Associate Editor-in-Chief, for their support and guidance. Lastly, our deep gratitude extends to the efforts of the *IEEE Communications Magazine* staff.

Biographies

Yongmin Choi [M] (yongminc@hotmail.com) received his B.S. and M.S. degrees in electronic engineering from Seoul National University, Korea, and his Ph.D. degree in electrical engineering from the University of Southern California, the USA. His professional career has spanned diverse fields in the telecommunications industry. His current interests include architecture and technologies for future networks including 6G, inductive analysis and modeling of network traffic, and cryptocurrency. He is a member of Phi Kappa Phi and Eta Kappa Nu.

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Yulin Shao [M'20] (ylshao@um.edu.mo) received the Ph.D. degree in Information Engineering from the Chinese University of Hong Kong. He was a research assistant with the Institute of Network Coding, a visiting scholar with the Research Laboratory of Electronics at Massachusetts Institute of Technology, and a research associate with the Department of Electrical and Electronic Engineering at Imperial College London. He is currently an Assistant Professor at the State Key Laboratory of Internet of Things for Smart City, University of Macau. His research interests include wireless communications and networking, machine learning, and stochastic control. He received the Best Paper Award at IEEE International Conference on Communications 2023.

Jie Zhang (jie.zhang@sheffield.ac.uk) has held the Chair in Wireless Systems at the Department of Electronic and Electrical Engineering, University of Sheffield, Sheffield, U.K., on a part-time basis, since January 2011. He is also the Founder, a Board Director and the Chief Scientific Officer of Ranplan Wireless, Cambridge, U.K. He received a Ph.D. degree in industrial automation from East China University of Science and Technology, Shanghai, China, in 1995. Prior to joining the University of Sheffield, he had worked with Imperial College London, Oxford University, and University of Bedfordshire, reaching a status of Senior Lecturer, Reader and Professor in 2002, 2005 and 2006, respectively.