EURASIP Journal on Wireless Communications and Networking

EDITORIAL Open Access

Artificial intelligence (AI) and machine learning (ML) for beyond 5G/6G communications

Mohammad Abdul Matin[1*], Sotirios K. Goudos[2], Shaohua Wan[3], Panagiotis Sarigiannidis[4] and Emmanouil M. Tentzeris[5]

*Correspondence: mohammad.matin@northsouth.edu; matin.mnt@gmail.com

[1] Department of Electrical and Computer Engineering, North South University, Dhaka, Bangladesh
[2] Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[3] Shenzhen Institute for Advanced Study, University of Electronic Science and Technology of China, Shenzhen 518110, China
[4] Department of Electrical and Computer Engineering, University of Western Macedonia, Kozani, Greece
[5] School of Electrical and Computer Engineering, Georgia Tech, Atlanta, USA

Over the past few years, we have seen there is huge growth with new opportunities in using digital technologies for a wide range of services across modern society and across the economy which has influenced our daily life in some ways. Artificial intelligence and machine learning are the fastest growing and more demanding at the heart of those innovative digital technologies/services. The expectation from beyond 5G /6G communication systems is to provide services with higher system capacity, low latency, high reliability, greater spectral efficiency as well as enabling massive Internet of things (IoT). It will be very difficult to achieve these requirements without automation of the network systems. Therefore, all prospective uses of AI/ML must be taken into consideration during the design of future wireless networks in order to realize the vision of an intelligent network that will facilitate automation in network management and operations. The articles in this special issue highlight current research and development (R&D) trends and findings in design, management, and optimization of B5G/6G networks with the use of AI/ML.

The article by Georgios P. Koudouridis et al. suggests a framework that offers three different AI architectural options: centralized, fully decentralized, and hybrid. The framework, in more detail, recognizes the logical AI functions, establishes how they map to the B5G radio access network architecture, and examines the deployment cost elements, notably the compute, communicate, and store costs. Based on a use case scenario for heterogeneous networks, the framework is assessed. It is demonstrated that the deployment cost profiling varies for the various AI architecture possibilities, and that this cost should be taken into account when deploying and choosing the AI/ML solution.

The most promising concept in B5G seems to be cell-free massive MIMO (CF M-MIMO) technology. CF M-MIMO systems have some drawbacks despite their enticing features, including power distribution and channel estimation. In a variety of scientific fields, including wireless communications, deep learning (DL) has been effectively applied to a wide range of challenges. *The article by Lazaros Alexios Iliadis et al.* provides a review of the most recent DL techniques used in CF M-MIMO communication

systems. The most popular DL models are presented along with the introduction of cell-free networks' fundamental properties. The directions for future research are highlighted at the end.

The Internet of things (IoT) and Internet of vehicles (IoV) are expanding quickly into 6G networks, which is raising security concerns significantly. One of the more useful methods is to use machine learning, including deep learning, to detect malicious network traffic. *This article by Bin Sun et al.* suggests examining conversation dataset features and selecting appropriate ones to combine into one dataset in order to enhance the performance of malware and malicious traffic identification. The studies with real data demonstrate that conditioned dataset combinations can be used to improve algorithm performance and detection outcomes.

The article by Evandro C. Vilas Boas et al. provides a thorough overview of AI-based channel estimation for multicarrier systems for B5G/6G. First, it presents crucial background information on classical methods of channel estimation. Second, the classical learning, neural networks, and reinforcement learning pedagogies are used to examine the AI-aided channel estimation techniques. Finally, based on recent discoveries, it highlights upcoming research avenues and analyzes existing challenges.

The article by Narengerile et al. proposes a new beam training approach via deep reinforcement learning to take use of machine learning technologies that will be used to build sixth-generation (6G) communication networks. According to changes in the wireless channel, the proposed algorithm can transition between various beam training strategies, reducing total beam training overhead while attaining high energy or spectrum efficiency. The authors also design a beam training technique that, depending on the channel conditions, may adjust the number of activated radio frequency chains to maximize either energy efficiency or spectral efficiency.

Incorporating the environment's micro-variation effect into multi-sensor fusion architecture, *the article by Yunus Egi et al.* shows how to effectively estimate the signal power path loss (SPPL) of wireless communication systems. By extracting information from the 3D categorized terrain, such as the height and kind of obstructions in the line of sight (LOS) direction, the proposed model, unlike other empirical ones, would reduce the environmental limitations. Using the ICC and YOLO V5 algorithms, the suggested method aggregates the impact of the trees and buildings on SPPL. The findings show that estimating SPPL for the deployment of wireless communications systems has significantly improved.

The use of SLAM techniques on mobile devices with limited resources is hindered by the growing computing resource consumption. In visual SLAM systems, MEC technology and 5G ultra-dense networks make it possible to offload complicated computational operations to edge computing servers, overcoming terminal resource limitations and satisfying real-time computing demands. Through three categories—static SLAM, dynamic SLAM, and SLAM methods integrated with deep learning—*the article by Jiansheng Peng et al.* presents the research findings in the area of visual SLAM in detail.

In the article by Mahdi Abbasi et al., Internet packets are implemented using ternary content-addressable memory (TCAM). In contrast to other forms of software bundles, this memory enhances speed and decreases hardware bundles due to its parallel search capabilities. However, as the number of rules stored in its layers increases, so does the

power needed for finding, inserting, and removing new rules. Numerous architectural solutions have been put up to address this issue, but none of them include a strategy for cutting power usage while changing the rules in the TCAM memory. Two techniques for minimizing power usage during TCAM memory upgrades are implemented and evaluated in this article.

In article by George Amponis et al., a series of attacks on the Packet Forwarding Control Protocol (PFCP), which is present in the 5G core, are examined, described, developed, put into practice, and finally tested. The authors discovered that by sending unauthorized session control packets, it is possible to disable established 5G tunnels without affecting subscribers' connectivity to the NG-RAN, thus hindering the detection of said attacks. In a drone-based scenario including 5G tunneling between two swarms, the authors assess the identified PFCP attacks.

The guest editors believe that this special issue offers some insights into the state of the art in this area and encourage further research of the challenges plaguing this area of research as well as potential solutions for designing, managing, and optimizing B5G/6G networks using AI/ML. The Guest Editors deeply appreciate the reviewers for their thoughtful critiques. The Guest Editors also wish to thank Prof. Dr.-Ing. Eduard Jorswieck, Editor-in-Chief, JWCN and Springer staff for their efforts in the development of this special issue.

Published online: 23 January 2023