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Special issue on "AI and machine learning solutions in 5G and future networks"

Editorial

With more and more telecommunication networks around the world able to accept software-based monitoring and operation, the role of AI or ML-based approaches has continued to grow in both research labs and production deployments. The network is transitioning from a reactive system to an autonomous, intent-driven cognitive engine. The fifth special issue on "AI and machine learning solutions in 5G and future networks" showcases key advancements in Machine Learning (ML) for 5G and future networks, highlighting how these technologies are redefining the management, scheduling and assurance of next-generation mobile networks.

The selected papers reflect both the breadth and depth of current research, spanning traffic forecasting, intent-driven automation, reinforcement learning for resource allocation and small language models for standardization. In particular, the latter work also shows an emerging trend of LLM-based approaches to support future development and engagement with standards, complementing the established trend of direct operational interventions on the network. Collectively, these pieces of work underscore the central role of interpretable, robust and scalable ML in realizing 5G and future networks.

- **Machine learning in 5G operations**

Enhancing network resource management through machine learning for spatio-temporal beam-level traffic forecasting

Authors: Stephen Kolesh, Thomas Basikolo

Several contributions push the frontier of network resource management, demonstrating that feature engineering combined with gradient boosting models can outperform more complex deep learning techniques for traffic forecasting at the beam level. This paper shows how dual-pipeline GBDT frameworks, tailored to short and long-term predictions, yield high forecasting accuracy with practical interpretability and computational efficiency, establishing interpretable ML as a viable alternative to deep neural nets in ultra-dense 5G scenarios.

- **Cognitive automation and intent management**

CONDENSE: Cognitive intent-driven end-to-end network slicing with AI planning agents

Authors: Ajay Kattepur, Ian Burdick, Swarup Mohalik, Marin Orlic, Leonid Mokrushin

Next-generation network operation is increasingly intent-driven and autonomous. This paper introduces a modular, agent-based system for end-to-end network slice management that leverages AI planning agents to decompose high-level service intents into actionable sub-intents across radio, transport and core domains. This neuro-symbolic approach supports both standardised specifications and adaptability to dynamic performance requirements, continuing the shift from rule-based to AI-driven management in 5G and future networks.

- **Reinforcement learning for resource scheduling**

Enhancing multiuser scheduling in massive MIMO mobile channels

Authors: Sara Al-kokhon, Hossein Bijanrostami, Elaheh Bassak, Brad Stimpson, Elvino Sousa

This paper addresses the complexity of massive MIMO multiuser scheduling is approached with Deep Reinforcement Learning (DRL) and intelligent clustering. The presented winning ITU challenge solutions blend DRL with efficient neural architectures and ML-based clustering (e.g., HDBSCAN),

improving throughput, latency and fairness at reduced computational cost. These advances highlight the practical feasibility of ML-enhanced schedulers that adapt in real time to varying user mobility and channel conditions, a critical concern for scalable 5G systems.

- **Machine learning tailored to telecommunications**

QMOS: Enhancing LLMs for telecommunications with question-masked loss and option shuffling

Authors: Blessed Guda, Gabrial Zencha Ashungafac, Lawrence Francis, Carlee Joe-Wong

This issue also draws attention to custom small language models and retrieval-based solutions for telecommunications. This paper surveys advances in text embedding, prompt engineering and specialized LLM adaptation for domain-specific tasks, such as knowledge retrieval, network management language processing and interface automation. This work shows how small models can be used when combined with complementary technologies (e.g. RAG and fine-tuning) for deploying AI in real-world telecommunication environments.

Outlook

Collectively, these papers demonstrate the central role that ML plays in future networks, showing that ML is both powerful and interpretable, and can, with increasing ease, integrate with legacy and emerging architectures, and adapt on-demand to user and network dynamics. The convergence of symbolic AI, reinforcement learning and domain-driven engineering paves the way for fully autonomous, intelligent and sustainable mobile networks. These pieces of work align well with the ITU-T's own standards on autonomous networks [1] and active work of the Focus Group on AI-Native Networks [2].

The guest editors commend the authors for their contributions to making intelligent future networks a practical reality.

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[1] https://www.itu.int/myworkspace/#/t-rec/item?id=15735&lang=en
[2] https://www.itu.int/en/ITU-T/focusgroups/ainn/Pages/default.aspx

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