AI-based Communications and Signal Processing

The convergence of Artificial Intelligence (AI) with modern communication and signal processing frameworks has ushered in a new paradigm of intelligent, adaptive, and data-driven systems. Conventional signal processing and communication methods rely heavily on deterministic models and handcrafted algorithms, which exhibit limitations under dynamic, nonlinear, and uncertain channel conditions. AI-based techniques, particularly deep learning (DL) and reinforcement learning (RL), have demonstrated remarkable capabilities in modeling complex relationships, performing feature extraction, and optimizing end-to-end communication performance without explicit analytical formulations. This integration has led to substantial advancements in key areas such as intelligent channel estimation and equalization, adaptive modulation classification, beamforming optimization, interference cancellation, and autonomous resource allocation in next-generation networks. Moreover, deep neural networks and graph-based learning architectures have enhanced physical layer signal processing, while reinforcement learning has improved decision-making at the medium access and network layers. The adoption of AI-driven models is particularly significant for emerging technologies such as 6G, massive MIMO, vehicular networks, and IoT communication systems, where real-time adaptability and energy efficiency are critical. This paper provides a comprehensive overview of AI-enabled communication and signal processing techniques, discusses their algorithmic architectures, evaluates performance improvements over traditional approaches, and explores open research challenges, including model interpretability, generalization, and computational scalability. The study underscores AI's transformative role in shaping the future of intelligent communication systems and signal processing paradigms.