

Adaptive Beamforming in Terahertz 6G Networks Using Deep Reinforcement Learning Under Rain-Dense Atmospheric Conditions

Md. Sharif Uddin Shajib

Department of Electrical and Electronics
World University of Bangladesh
Dhaka, Bangladesh
Sharif.uddin@eee.wub.edu.bd

Mohammad Quamruzzaman, Md. Riyad Tanshen, Farhana Latif and Mst Sumi Akter

Department of Electrical and Electronics
World University of Bangladesh
Dhaka, Bangladesh

md.quamruzzaman@eee.wub.edu.bd, tanshen@eee.wub.edu.bd, farhana.latif@eee.wub.edu.bd,
sumi.akter@eee.wub.edu.bd

Abstract

The Terahertz (THz) spectrum is a key enabler for 6G networks due to its ability to deliver ultra-high data rates and sub-millisecond latency. However, THz signals experience severe propagation challenges, including high path loss, molecular absorption, and extreme sensitivity to rain, making outdoor reliability a major bottleneck. This paper proposes a Deep Reinforcement Learning (DRL)-driven adaptive beamforming framework for Massive MIMO THz systems, employing a Tuned Soft Actor-Critic (TSAC) agent enhanced with Prioritized Experience Replay (PER), state-augmentation using the rain-rate derivative (ΔR), and an outage-averse reward design. Simulation results demonstrate that the proposed TSAC agent achieves zero outage up to 120 mm/hr rainfall and delivers up to $7.5\times$ higher throughput than conventional static or baseline DRL techniques. It consistently outperforms the oracle codebook beamformer, achieving ≈ 1.50 Gbps across all rain conditions while maintaining near-perfect link availability. These findings confirm that carefully tuned DRL architecture can provide robust and intelligent physical-layer adaptation for reliable THz communications under highly dynamic atmospheric conditions.

Keywords

Terahertz (THz) communication, Deep Reinforcement Learning, Adaptive Beamforming, 6G Networks, Rain Attenuation.