IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, December 2025
Impact Factor: 7.67

Enhancing Smart City Connectivity with Ultra-High Data Rate Millimeter-Wave and Terahertz Communication: A Machine Learning Approach

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Abstract: *Smart cities demand next-generation wireless communication technologies capable of supporting ultra-high data rates, low latency, and seamless connectivity. Millimeter-wave (mmWave) and Terahertz (THz) communication technologies have emerged as promising solutions to meet these requirements, offering wide bandwidth availability and high-speed data transmission. However, the propagation of high-frequency signals is significantly affected by severe path loss and complex channel characteristics. To address these challenges, this paper proposes a machine learning–assisted channel estimation framework aimed at enhancing connectivity in smart city environments. The proposed approach integrates convolutional neural networks (CNNs) with long short-term memory (LSTM) networks to accurately predict channel conditions and dynamically optimize transmission parameters. Simulation results demonstrate a 30% improvement in spectral efficiency, a 25% reduction in mean square error (MSE) for channel estimation, and an 8 dB enhancement in signal-to-noise ratio (SNR) compared to conventional methods. Furthermore, the proposed system achieves a 20% reduction in latency, ensuring reliable and efficient data transmission for smart city applications. These findings highlight the potential of combining machine learning with mmWave and THz communication technologies to enable next-generation high-capacity wireless networks in urban environments.*

Keywords: Smart Cities, Millimeter-Wave Communication, Terahertz Communication, Ultra-High Data Rate, Machine Learning, Channel Estimation, Wireless Networks

DOI: 10.48175/IJARSCT-30657