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Gen-TWIN: Generative-AI-Enabled Digital Twin for Open Radio Access Networks

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How does Gen-TWIN enhance the scalability and accuracy of Digital Twin-based RAN optimization compared to traditional methods? What are the key advantages of using a soft-attention LSTM-based GAN (soft-GAN) for synthetic RF data generation in DT-RAN applications? How does the integration of Generative AI in Digital Twins address the data scarcity challenge in training AI models for O-RAN?

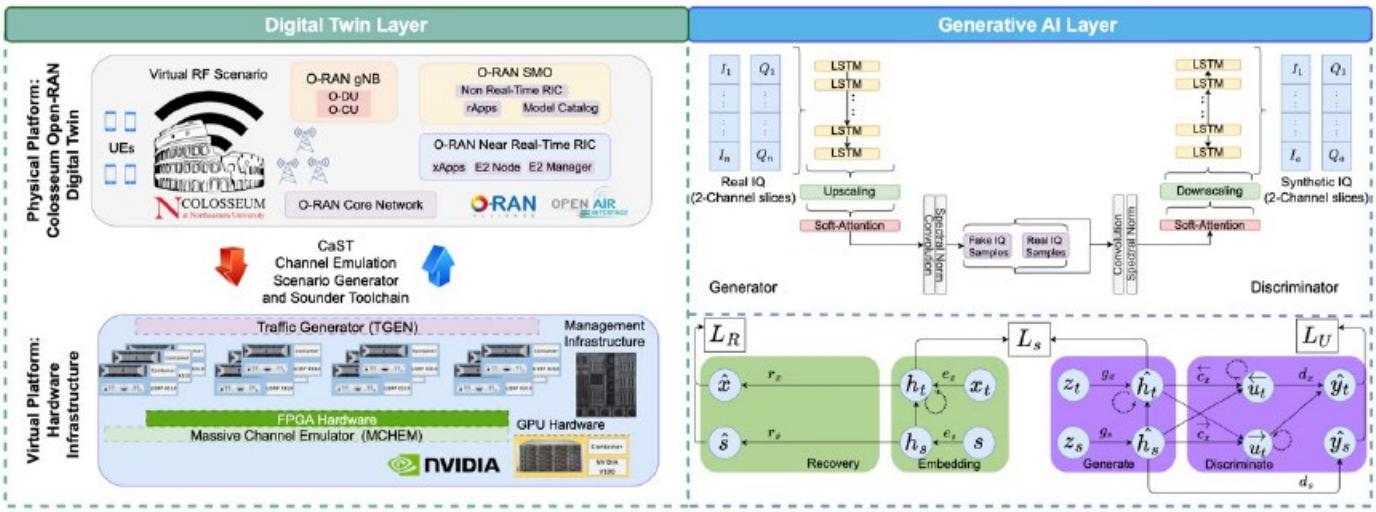

Figure illustrates the Gen-TWIN framework, integrating a Digital Twin Layer and a Generative AI Layer. The Digital Twin Layer includes O-RAN SMO, Near-Real-Time RIC, and Colosseum for RF scenario emulation. The Generative AI Layer features a soft-attention LSTM-based GAN (soft-GAN) for IQ data synthesis. The generator and discriminator modules utilize spectral norm convolution and embedding techniques to enhance synthetic RF data quality, enabling AI-driven RAN optimization.

KEY FINDINGS

Gen-TWIN is a novel Generative AI-enabled Digital Twin platform designed for Open RAN, addressing the scarcity of high-quality, site-specific RF datasets critical for AI-driven network optimization. It leverages a soft-attention LSTM-based GAN (soft-GAN) to generate realistic synthetic IQ data, significantly improving model training for DT-RAN. By augmenting empirical datasets, Gen-TWIN enhances the generalization ability of AI models, reducing dependency on costly real-world measurements. The proposed soft-GAN model outperforms baseline generative models by 19%, demonstrating superior data fidelity and network adaptation. The framework integrates O-RAN SMO, RICs, and Colosseum testbed, ensuring real-world applicability. This research highlights the transformative role of Generative AI in 6G, enabling scalable, adaptive, and energy-efficient Digital Twin implementations for future wireless networks.