Title	REST-UNet-Based Interference Mitigation for Concurrent PNC Scheme in Full-Duplex Wireless Networks
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Abstract

Wireless communication networks face immense pressure to support exponentially increasing data demands and ultra-low latency requirements, yet conventional half-duplex systems waste significant spectral resources due to their inability to transmit and receive simultaneously. This dissertation addresses the pressing need for enhanced throughput and reduced latency by advancing the concept of Physical-Layer Network Coding (PNC) into practical full-duplex operation.

Current wireless relay systems encounter severe performance bottlenecks due to residual self-interference (RSI) inherent in full-duplex operation, which persists even after analog cancellation. To overcome this fundamental limitation, we propose Concurrent Physical-Layer Network Coding (CPNC), the first full-duplex PNC framework that maintains compatibility with 5G New Radio specifications while incorporating a fixed processing delay δ to enable pipelined operation and systematic RSI management. CPNC achieves an average normalized throughput (ANT) of 1.73 at high SNR—a 73% improvement over conventional half-duplex PNC's theoretical limit of 1.0, while approaching 86.5% of the ideal full-duplex capacity.

To fully exploit CPNC's potential under realistic interference conditions, we introduce REST-UNet (Residual Attention U-Net), an innovative deep learning receiver architecture that jointly performs interference suppression, channel estimation, and XOR symbol detection through learned transformations. REST-UNet uniquely integrates multi-scale feature extraction with channel and spatial attention mechanisms, achieving approximately 62% uncoded BER reduction compared to conventional LS+MMSE+LDPC processing and 44% reduction over state-of-the-art DeepRx at 10 dB SNR, while maintaining robustness to channel variations up to 250 Hz Doppler shift.

The seamless integration of REST-UNet into the CPNC framework creates the first comprehensive AI-enhanced full-duplex PNC system. Extensive simulations across diverse ITU indoor scenarios reveal critical design parameters: a minimum RSI suppression threshold of -15 dB for reliable operation, an optimal relay timing window of about 30 μs, and consistent performance gains across various propagation conditions. The integrated system maintains BER below 10^{-5} even with practical RSI levels, demonstrating feasibility for real-world deployment.

This research pioneers the convergence of concurrent network coding with AI-enhanced signal processing, delivering practical solutions to the fundamental challenges of full-duplex communication. The proposed framework not only demonstrates substantial throughput gains and latency reduction but also lays the foundation for future 6G wireless systems, where ultra-reliable low-latency communication (URLLC) is paramount.

Keywords: Physical-Layer Network Coding (PNC); Full-Duplex Communication; Residual Self-Interference; Deep Learning; REST-UNet; Concurrent Network Coding; 5G New Radio; URLLC