In recent decades, the wireless communication industry has attracted a great deal of research efforts to satisfy rigorous performance requirements and preserve high spectral efficiency. Along with this trend, I/Q modulation is frequently applied in modern wireless communications to develop high performance and high data rate systems. This has necessitated the need for applying efficient complex-valued signal processing techniques to highly-integrated, multi-standard receiver devices.

In this dissertation, novel techniques for complex-valued digital signal enhancement are presented and analyzed for various applications in wireless communications.

The first technique is a unified block processing approach to generate the complex-valued conjugate gradient Least Mean Square (LMS) techniques with optimal adaptations. The proposed algorithms exploit the concept of the complex conjugate gradients to find the orthogonal directions for updating the adaptive filter coefficients at each iteration. Along each orthogonal direction, the presented algorithms employ the complex Taylor series expansion to calculate time-varying convergence factors tailored for the adaptive filter coefficients. The performance of the developed technique is tested in the applications of channel estimation, channel equalization, and adaptive array beamforming. Comparing to the state of the art methods, the proposed techniques demonstrate improved performance and exhibit desirable characteristics for practical use.

The second complex-valued signal processing technique is a novel Optimal Block Adaptive algorithm based onCircularity, OBA-C. The proposed OBA-C method compensates for a complex imbalanced signal by restoring its circularity. In addition, by utilizing the complex Taylor series expansion, the OBA-C method optimally updates the adaptive filter coefficients at each iteration. This algorithm can be applied to mitigate the frequency-dependent I/Q mismatch effects in analog front-end. Simulation results indicate that comparing to the existing methods, OBA-C exhibits superior convergence speed while maintaining excellent accuracy.

The third technique is regarding interference rejection in communication systems. The research on both LMS and Independent Component Analysis (ICA) based techniques continues to receive significant attention in the area of interference cancellation. The performance of the LMS and ICA based approaches is studied for signals with different probabilistic distributions. Our research indicates that the ICA-based approach works better for super-Gaussian signals, while the LMS-based method is preferable for sub-Gaussian signals. Therefore, an appropriate choice of interference suppression algorithms can be made to satisfy the ever-increasing demand for better performance in modern receiver design.

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The public is welcome to attend.