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LMS-NEWTON ADAPTIVE FILTERING USING FFT–BASED CONJUGATE GRADIENT ITERATIONS *

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Abstract. In this paper, we propose a new fast Fourier transform (FFT) based LMS-Newton (LMSN) adaptive filter algorithm. At each adaptive time step t, the nth-order filter coefficients are updated by using the inverse of an n-by-n Hermitian, positive definite, Toeplitz operator $T(t)$. By applying the cyclic displacement formula for the inverse of a Toeplitz operator, $T(t)^{-1}$ can be constructed using the solution vector of the Toeplitz system $T(t)\mathbf{u}(t) = \mathbf{e}_n$, where $\mathbf{e}_n$ is the last unit vector. We apply the FFT–based preconditioned conjugate gradient (PCG) method with the Toeplitz matrix $T(t-1)$ as preconditioner to solve such systems at the step t. As both matrix vector products $T(t)\mathbf{v}$ and $T(t-1)^{-1}\mathbf{v}$ can be computed by circular convolutions, FFTs are used throughout the computations. Under certain practical assumptions in signal processing applications, we prove that with probability 1 that the condition number of the preconditioned matrix $T(t-1)^{-1}T(t)$ is near to 1. The method converges very quickly, and the filter coefficients can be updated in $O(n \log n)$ operations per adaptive filter input. Preliminary numerical results are reported in order to illustrate the effectiveness of the method.

Key words. LMS-Newton adaptive filter algorithm, finite impulse response filter, Toeplitz matrix, circulant matrix, preconditioned conjugate gradient method, fast Fourier transform.

AMS subject classification. 65F10.

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