



AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Communications Engineering Department

Effect of Roundoff Errors on Nonstationary Adaptive Filtering

A Thesis

Submitted in Partial Fulfillment for the Requirements
of the Degree of Master of Science in Electrical Engineering
(Electronics and Communications Engineering)

Submitted By



Waleed Mamdouh Younis

B.Sc. of Electrical Engineering
(Electronics and Communications Engineering)
Ain Shams University, 1995

Supervised By

Prof. Dr. Eweda Ibrahim Eweda
Prof. Dr. Salwa Hussein El-Ramly

Cairo - 1998







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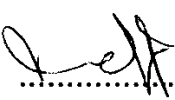
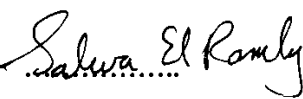
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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Electronics and Communications Engineering).

The work included in this thesis was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or qualification at other university or institution.

Date : / / 1998

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ABSTRACT

Waleed Mamdouh Younis. Effect of Roundoff Errors on Nonstationary Adaptive Filtering. Master of Science dissertation, Ain Shams University, 1998.

Nowadays, adaptive filtering has attained a great importance in the field of high speed digital communications due to its various applications such as system identification, noise cancellation, adaptive equalization, and others. In digital implementation of adaptive filters, the input data, the adaptive filter coefficients, and the internal calculations are quantized to finite precision determined by the design and cost considerations. Most of the available analyses of adaptive filters are concerned with the infinite precision case. Roundoff error effects on the performance of adaptive filters were analyzed for stationary systems only. Roundoff error effects on adaptive filters operating in a nonstationary environment have not yet been analyzed in literature. This will be the main goal of the thesis

The thesis provides roundoff error analyses of the least mean square (LMS) algorithm, the signed regressor algorithm (SRA), and the sign algorithm (SA) in a nonstationary environment. Expressions for the steady state mean square error (MSE) and the steady state mean square weight deviation (MSWD) are derived. It is shown that both of these measures decrease as the filter coefficients wordlength increases. It is found also that there exists an optimum step size that minimizes the MSE and another that minimizes the MSWD. Expressions are derived for the optimum step sizes and the corresponding MSE and MSWD, respectively. The thesis provides also the conditions at which the effect of nonstationarity dominates (or is dominated by) the effect of finite wordlength.

The tracking performance of the quantized block implementation of the LMS algorithm and its signed variants is also analyzed. Expressions are derived for the MSE and MSWD of the block least mean

square (BLMS) algorithm, the block signed regressor algorithm (BSRA), and the block sign algorithm (BSA). It is found that the block algorithms possess a higher resistance to roundoff error effects than the corresponding conventional algorithms. The MSE and MSWD are found to be decreasing functions of the block length. Upper and lower bounds of the block length are derived for each algorithm. A comparison of the above algorithms is performed.

Finally, a comparison of the linear and nonlinear theories for analyzing the quantization error effects is performed. For the LMS algorithm, it is found that the nonlinear theory provides more accurate results than the linear one in the cases where the stopping phenomenon occurs. When the algorithm step size is chosen to avoid the stopping phenomenon, the linear theory is found to be more advantageous than the nonlinear one since the former provides closed form performance equations which enable easy design of the algorithms while the latter provides complicated equations that can be solved only numerically. For the sign algorithm, it is shown that the linear theory is sufficient for the roundoff error analysis. Expressions are derived for the minimum step sizes at which the linear theory is applicable to the LMS algorithm and its signed variants. All analytical results derived in the thesis are validated by computer simulations. The simulation results are found to be in good agreement with the analytical ones.

Keywords: *Adaptive signal processing, Adaptive filtering algorithms, Roundoff errors.*