Radioelectronics and Communications Systems
Vol. 48, No. 2, pp. 51–56, 2005

Izvestiya VUZ. Radioelektronika
Vol. 48, No. 2, pp. 72–80, 2005
UDC 621.513.6

A FAST RLS-ALGORITHM FOR LINEARLY CONSTRAINED ADAPTIVE FILTERING OF NONSTATIONARY SIGNALS

V. I. Dzhigan

GUP NPTs "ELVIS", Moscow, Russia

A fast RLS-algorithm of multichannel adaptive filtering with a sliding window and linear constraints is suggested. The algorithm represents a fast (effective in the computational sense) version of the similar RLS-algorithm based on the inverse QR-decomposition. A peculiar feature of the algorithm is absence of square root operations in it.

Among the contemporary algorithms of adaptive processing of signals, recursive algorithms using the least squares criterion (Recursive Least Squares — RLS) [1] are considered most effective from the viewpoint of their transient process duration and the level of residual error in steady-state conditions. All RLS algorithms necessitate calculation of the correlation matrix of input signals of the adaptive filter. This matrix may be determined on an increasing or on a sliding window (SW) of the data to be processed. The sliding window permits the adaptive filter to track effectively various changes when processing non-stationary signals. Most of adaptive filtration algorithms are based on the methods of unconstrained optimization. However, in a number of cases, the conditional (linearly constrained — LC) optimization is employed. For development of computational procedures in SW RLS and LC SW RLS-algorithms, various mathematical methods are used, including QR-decomposition of the matrix of input signals of the adaptive filter. A disadvantage of adaptive algorithms based on QR-decomposition is that they cannot do without taking the square root requiring additional computational resources. In RLS-algorithms using the direct QR-decomposition, these operations can be avoided by scaling some variables [2]. The same technique has been applied in [3] for the LC SW RLS-algorithm based on the inverse QR-decomposition.

The present work is devoted to a fast (effective in the computational sense) version of the algorithm described in [3], and represents its full mathematical analog. It means that at identical parameters of adaptive filters, operating under the same conditions, both algorithms exhibit identical quality of adaptive filtering when the algorithms are realized in the floating-point arithmetic. The difference between both algorithms consists in their computational procedures, i.e., in the number of arithmetic operations spent on implementation of one iteration.

The part of computations associated with linear constraints (steps 19–22 and 26–29 of the algorithm described in [3]) is the same for both algorithms. But the vectors of Kalman's coefficients $g_{N,\chi_U}(k)$ and $g_{N,\chi_D}(k)$ are calculated in different ways. In the case of the fast algorithm, these vectors are determined as shown in Table 1 illustrating the computational procedure of the new LC SW RLS-algorithm of adaptive filtering.

In Table 1, C_{NJ} is the matrix of J linear constraints; f_J is the vector of values of a parameter to be constrained;

$$h_N^H(k) = \left[h_{N_1}^H(k), h_{N_2}^H(k), \ldots, h_{N_m}^H(k), \ldots, h_{N_{M-1}}^H(k), h_{N_M}^H(k)\right]$$

is the vector of weight coefficients of the M-channel adaptive filter;

REFERENCES

1. A. H. Sayed, Fundamentals of Adaptive Filtering, John Wiley and Sons, Inc., Hoboken, NJ, 2003.

2. S. F. Hsieh and K. J. R. Liu, IEEE Trans. Signal Processing, Vol. 41, No. 3, pp. 1405–1409, 1993.

3. V. I. Dzhigan, Izv. VUZ. Radioelektronika, Vol. 47, No. 8, pp. 29–38, 2004.

4. G. Zelniker and F. J. Taylor, Advanced Digital Signal Processing: Theory and Applications, Marcel Dekker, Inc., New York, 1994.

5. N. Kalouptsidis and S. Theodoridis (editors), Adaptive system identification and signal processing algorithm, Prentice-Hall, Englewood Cliffs, NJ, 1993.

6. I. K. Prouder, IEE Proceedings: Vision, Image and Signal Processing, Vol. 141, No. 5, pp. 325–333, 1994.

7. G. A. Glentis and N. Kalouptsidis, IEEE Trans. Signal Processing, Vol. 40, No. 10, pp. 2433–2458, 1992.

8. V. I. Dzhigan, Izv. VUZ. Elektronika, No. 1, pp. 83–90, 2004.

9. 6. S. L. Gay, Dynamically regularized fast RLS with application to echo cancellation, Proc. ICASSP'96, pp. 957–960, May 1996.

14 May 2004