A New LMS for Beamforming In Mobile Communication

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Abstract - ***In the recent years, adaptive or smart antennas have become a key component for various wireless applications, such as radar, sonar, and 4G cellular mobile communications. The Least Mean Square (LMS) and its normalized version (NLMS) are the workhorses of adaptive filtering. In the presence of correlated input signals, the LMS and NLMS algorithms have extremely slow convergence rates.Beamforming using antenna array is promising and necessary task in the next generation wireless and mobile systems. The important tasks considered in array processing are beamforming, Angle Of Arrival (AOA), Direction Of Arrival (DOA) estimation and source tracking.An advance NEW LMS or IMPROVED LMS is proposed which reduces the Mean Square Error and increases the convergence speed by a large amount as compared to existing beamforming algorithms. A NEW LMS algorithm will provide excellent convergence characteristics.***

Keywords *— Adaptive array beamforming, LMS, new LMS algorithm, Mean square error.*

[1] INTRODUCTION

The purpose of beamforming is to form a multiple beams towards desired users while nulling the interferers at the same time, through the adjustment of the beamformer's weight vectors. A beamformer is a set of sensors (antennas), arranged in a linear fashion (Uniform Linear Array), that extract spatial information from the waves emitted by signal sources in order to steer the beam electronically towards the look direction and nulls in the jammer directions.

We have to compare the three basic algorithms, Least Mean Square (LMS) algorithm, Leaky LMS (LLMS) Beamformer and NEW (IMPROVED) LMS algorithm on the performance basis using MATLAB simulation.

[2] LITERATURE SURVEY:

H. V. Kumaraswamy et al.[1] have proposed and designed a new scheme of LMS implementation to minimize the Mean Square Error (MSE), and to increase the convergence rate. They analysed the model of NEW LMS algorithm and its characteristics using MATLAB simulation. For comparison purposes, results obtained with the conventional LMS and VSS-LMS algorithm are also presented.

Another method for improving LMS/N-LMS based beamforming using Shirvani-Akbari Array, was developed by ShahriarShirvaniMoghaddam et al.[2]. They analysed the model for Array Processing and Adaptive Array Beamforming. Their Simulation results shows improved convergence speed and accuracy in data transmission considering Array Factor (AF), MSE and Bit error Rate (BER) performance metrics for the new array, especially for low SNRs.

Performance of Beamforming for Smart antenna using Traditional LMS algorithm was studied by M.S.Chavan et al.[3]. The Least Mean Square (LMS) algorithm is an adaptive algorithm. This algorithm can be applied to beam forming with the software MATLAB. They have discussed the performance of adaptive beamforming using traditional LMS algorithm used in smart antenna. For different number of array element and different spacing between elements are considered for simulation. It was found that sharper beams are directed towards desired signals as more elements are used in antenna array. The results obtain can achieve faster convergence and lower steady state error.

Another new approach of, A Simple Adaptive Beamforming Algorithm with interference suppression, was developed and implemented by Dr. A. P. Kabilan et al.[4]. They have modelled a linear array of antennas for 20º Half Power Beam Width (HPBW) and obtained the beam formation with digital modulation of 16 point Quadrature Amplitude Modulation (QAM). This modulation technique is used for the systems like CDMA, Wi-Fi (IEEE802.11) and WiMAX (IEEE-802.16). This technique improves the system capacity and minimizes the bit error rate (BER) up to 10-4 for the signal to noise ratio of 13dB's. Results obtained verify the improved performance of the smart antenna system, indicating the desired users, and deep nulls in the array pattern.

Traditional LMS beamforming algorithm has certain drawbacks regarding to the convergence rate, Mean Square Error (MSE) and stability. B. G. Hogade et al.[5] has developed a new Improved LMS beamforming algorithm for smart antenna for the optimal performance. Smart antenna can provide higher system capacities, increase signal to noise ratio, reduce multipath and co-channel interference and forming nulls in the direction of the interfering signal. The simulation results shows that, in traditional LMS step size is fixed where as in improved LMS step size is variable. And hence, traditional algorithm has slow convergence speed compared to improved LMS algorithm. Also it was found that the performance of LMS beamformer improves as more elements are used in the antenna array.

In addition to LMS implementation for beamforming, "A Recursive Least Squares For LCMP Beamforming Under Quadratic Constraint" was developed by ZhiTian et al.[6]. Quadratic constraints on the weight vector of an adaptive linearly constrained minimum power (LCMP) beamformer can improve robustness to pointing errors and to random perturbations in sensor parameters. He described a robust adaptive beamformer that uses variable loading for implementing a quadratic inequality constraint with recursive least square updating. It is capable of providing robust control over beamformer responses with computational efficiency.

[3] LEAST MEAN SQUARE ALGORITHMS (LMS):

LMS is the most widely used and simple algorithm, which uses a gradient-based method of steepest descent. The algorithm updates the weights recursively by estimating gradient of the error surface and changing the weights in the direction opposite to the gradient to minimize the Mean Square Error (MSE). LMS algorithm employed in many communication applications.

The error signal is the difference between desired signal, d(n), and array output, y(n), computed by the expression:

$$e(n) = d(n) - y(n) \quad (1)$$

According to the LMS algorithm, the final recursive equation for updating the weight vector is:

$$w(n+1) = w(n) + \mu x(n)e^*(n) \quad (2)$$

μ is the step size parameter which controls the convergence speed of the algorithm. Step size is a major parameter that makes a trade-off between the convergence speed and the LMS stability.

[4] LEAKY LMS (LLMS) BEAMFORMER:

The noise is added to the autocorrelation matrix in this algorithm, using Leaky factor. This matrix has zero eigen values, in some cases. This causes LMS algorithm to have un-damped modes. It is important to stabilize the LMS by forcing these modes to zero. To accomplish this, we introduce leakage coefficient γ, which is in the range 0<γ<1 into auto correlation matrix, step size calculation and weight vector equation. The weight update equation is given by

$$W(n+1) = [1-\mu\gamma]W(n)+\mu e^*(n)x(n) \quad (3)$$

Where, μ is step size,

$$\mu = \frac{2}{\lambda_{max} + \gamma} \quad (4)$$

Where λ_{max} is the maximum eigen value

[5] NEW (IMPROVED) LMS ALGORITHM:

The traditional LMS algorithm is simple, having less computational complexity. However, its convergence rate is slow. So we have to implement an improved scheme for LMS algorithm, to form a modified LMS algorithm. The scheme consists of, one feedback module called as converse-speediness module, two LMS algorithm modules and one speediness module, which connects two LMS algorithm modules.

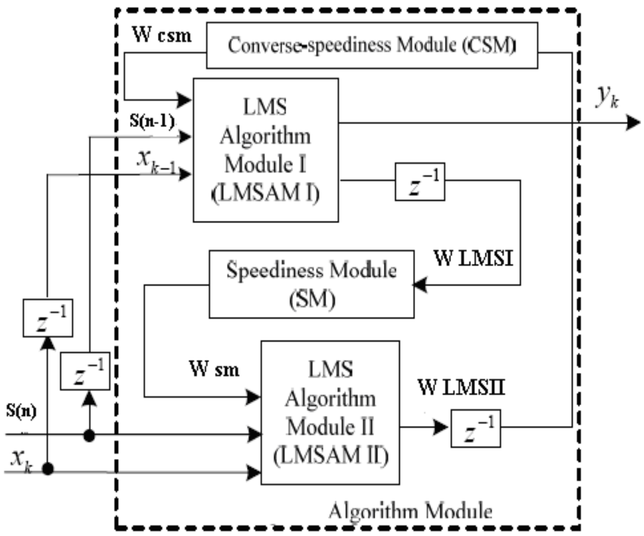

Fig.1-Block diagram of NEW LMS algorithm

A NEW LMS scheme is very much similar to the structure of the turbo decoder. It has four main components: LMS algorithm ModuleI (LMSAM I), LMS algorithm ModuleII (LMSAM II), Speediness Module (SM) and Convergence Speediness Module (CSM).

LMSAM I and LMSAM II both use conventional LMS algorithm. The main purpose of LMS algorithm is to find a proper weight vector (Wk) which can make the MSE of the system output and the reference signal minimum.

$$\lim_{k\to\infty} \frac{w_{k-1}-w_s}{w_k-w_s} = \text{constant}, k = 1, 2 \ldots\ldots \quad (5)$$

Where, k is the number of iterations, and $w_s$is the stable-state weight vector. Convergence Speediness Module (CSM) gets the weight vector $w_{csm}$from calculating the weight vector (w_{LMSII}) of LMSAM II and then feeds back $w_{csm}$to LMSAM I. w_{csm}Obtained in CSM is closer to the stable-state weight vector (w_s) than the weight vector (w_{LMSI}) computing in LMSAM I. Therefore both LMSAM I and LMSAM II are having accelerating convergence rates.

[6] Proposed Work:

Basically beamforming is a technique of directional signal transmission and recitation. Adaptive beamforming is a powerful technique of enhancing a signal of interest while suppressing the interference signal and the noise at the output of an array of sensors. The most mainly used adaptive algorithms include LMS (Least Mean Square), SMI (Sample Matrix Inversion) and RLS (Recursive Least Square). From the recent inventions, it is observed that for fast convergence with large number of iteration, LMS is suitable.

There are some drawbacks while using traditional LMS algorithm. LMS and LLMS converges for more iterations, takes much amount of execution time. We have to implement a modified algorithm which will be better compared to existing beamforming algorithms in terms of MSE characteristics and convergence.

The proposed work is to carry out the design and implementation of the Improved (or) NEW LMS algorithm for beamforming in mobile communication, which will result into improved convergence rate with minimum Mean Square Error (MSE) compared to the traditional LMS algorithm.

[7] METHODOLOGY:

First, we are going to study the old LMS (Least Mean Square) and L-LMS (Leaky-LMS) algorithms regarding to the convergence rate, Mean square Error (MSE) and Stability parameters for beamforming in mobile communication. MATLAB simulation results show that these methods have some drawbacks.

To overcome the drawbacks of old LMS algorithm, we are implementing an improved algorithm which can be simulated and analysed using MATLAB software. It includes calculation of convergence speed and Mean Square Error (MSE).

Aim of this dissertation work is to study, design and implement a modified NEW LMS algorithm.

The proposed work is divided into following three groups.

Study of traditional and leaky LMS algorithms.

Design of an NEW LMS algorithm.

Implementation and analysis of NEW LMS algorithm using MATLAB software.

Comparison of these algorithms on the MATLAB simulation performance basis.

[8] Performance Parameters:

Validation will be done by comparison between the simulation results of three algorithms on the basis of following datum:

Convergence speed.

Mean Square Error.

Stability.

[9] Conclusion-

A new adaptive algorithm for beamforming is presented and analyzed. The performance is compared with existing LMS algorithm and new LLMS algorithm. It is shown that the proposed new LMS algorithm can achieve rapid convergence. Unlike conventional LMS and LLMS, new LMS takes less amount of execution time.

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