PERFORMANCE OF MIR-LMS ALGORITHM FOR ADAPTIVE BEAM FORMING IN SMART ANTENNA

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Abstract— In this paper a Matrix Inverse Robust Least Mean Square (MIR-LMS) algorithm is propose where we uses the sample Matrix Inversion (SMI) algorithm and ratio parameters to control the contribution of normalized product vectors in the weight upgradation process. The idea behind this proposed algorithm is that we not only consider the present error vector but also the previous one with normalized received signal whose initial weight is upgraded by the SMI algorithm for the weight upgradation process. When the proposed algorithm compares with standard one than we see the performance enhancement is there in MIR-LMS algorithm we find that the signal response is improved, the convergence rate is faster with less Brownian motion and it suppress the interference angle of arrival (AOA) and direct the beam towards the desired user angle of arrival (AOA).

Keywords— Matrix Inverse Robust Least Mean Square (MIR-LMS), Robust LMS (R-LMS), Sample Matrix Inversion (SMI), Mean Square error (MSE), Signal Response, Beam Forming

I. INTRODUCTION

The smart antenna system is the combination of an array of antenna with a signal-processing capability to transmit and receive in an adaptive, spatially sensitive manner. The smart antenna radiation pattern nullifies the interference (unwanted) signal angle of arrival and direct the beam towards the desired (wanted) signal angle of arrival, by this the capacity of the system is improved and this process also leads to maximize the Signal to Interference Ratio (SIR), indeed maximizes the throughput of the network.

II. LMS ALGORITHM

The smart antenna radiation pattern is shaped according to some adaptive algorithms. A very computationally efficient adaptive algorithm is the least mean squares (LMS) algorithm which is invented by Stanford's professor Bernard Widrow and PhD student Ted Hoff in 1959. Where y (t) is the array output

$y(t)=W^H X(t)$ (1)

The LMS algorithm estimates the gradient of the error signal, e (t), by employing the method of steepest descent. The error signal is defined as the difference between the desired signal and the output signal.

$e(t)=S(t)–y(t)=S(t)–W^H X(t)$ (2)

When using the lms algorithm, the set of weighting element is initially set to zero. That is wo= 0 using an above equation error signal is generated by comparing y(t) with the desired signal s (t) and then this error signal is used to update the weight vector using equation

$W(t+1)=W(t)+\mu X(t)e^*(t)$ (3)

where: μ is step size parameter or weight convergence parameter. It is a real valued positive constant whose value lies between zero and 1. For large value of μ, we have fast convergence but lower the stability around the minimum value. On the other hand, for small value of μ, we have slow convergence but with higher stability around the optimum value. The speed of convergence also depends upon the Eigen structure of Rxx for optimum weight μ satisfy the following conditions where λmax is maximal Rxx Eigen value

$0< \mu < 2/ \lambda_{max}$ (4)

one of its great weaknesses of LMS algorithm is its slow convergence rate. To improve the performance of system we have implemented a new algorithm.

III. ALGORITHM DEVELOPMENT

A Matrix Inversion Robust Least Mean Square (MIR-LMS) adaptive algorithm was proposed for smart antenna application. The MIR-LMS is the combine of individual good aspects of Sample Matrix Inversion (SMI), Robust Least Mean Square (R-LMS) and the Normalized Least Mean Square (NLMS) algorithm. The weight coefficients derived by SMI algorithm are set as initial coefficients and are updated by introducing Robust LMS and NLMS algorithm.

In practice, the signals are not known and the signal environment frequently changes so we require an adaptive processor which must continuously update the weight vector to compensate the varying condition of the channel, for that an optimal weight vector can be derived by the estimation of covariance matrix Rxx and the cross-correlation matrix rsx in a finite observation interval and then these estimates are used to obtain the desired vector.

$$R_{xx} = \sum_{i=N1}^{N2} X(t)X^H(t) \quad (5)$$

$$r_{sx} = \sum_{i=N1}^{N2} S^*(t)X(t) \quad (6)$$

and the optimum weight is

$$W_{optm}=(R_{xx})^{-1}r_{sx} \quad (7)$$

time interval between N1 and N2 should be supposed to be less because if time interval is large then it will take more time in matrix inversion and the output signal will be obtained by

$y(t)=W^H X(t)$

here we consider present and previous error signal for robustness which are as follows

$e(t) = S(t) – y(t)$

$e(t-1) = S(t-1) – y(t-1)$

weight up gradation equation of the MIR - LMS algorithm is given below

$$W(t+1) = W(t) + \mu[(\gamma_1 X(t)e^*(t))/\|X(t)\|^2 + (\gamma_2 X(t-1)e^*(t-1))/\|X(t-1)\|^2] \quad (8)$$

Likewise in R-LMS here ratio parameters γ_1 and γ_2 control the amount by which current product e (t) X (t) and the previous product e (t−1) X (t−1) contribute to the weight up gradation respectively. Let us introduce a notation for the normalized product vectors for future reference as:

$$\square_1 = X(t)e^*(t)/\|X(t)\|^2 \quad (9)$$

$$\square_2 = X(t-1)e^*(t-1)/\|X(t-1)\|^2 \quad (10)$$

There are some constraints placed on the selection of ratio parameters. The constraint on each ratio parameter is

$0 \le \gamma_1 \le 1$

$0 \le \gamma_2 \le 1$

These constraints prevent the current normalized product vector and the previous normalized product vectors from having a negative multiplier, which may alter the proper weight up gradation process. One additional constraint is given by equation:

$\gamma_1 + \gamma_2 = 1$

Putting $\gamma_1 =1$, $\gamma_2 =0$ in equation 8 yield

$W(t+1)=W(t)+\mu\square_1$

Substituting value of $\square_1$ from equation 9 in above equation results in

$$W(t+1)=W(t) + \mu X(t)e^*(t)/\|X(t)\|^2 \quad (11)$$

which is weight up gradation equation of conventional MI-NLMS algorithm. Hence MI-NLMS algorithm can be seen as a special case of MIR-LMS algorithm with $\gamma_1=1$, $\gamma_2=0$ using equation 9,10 in equation 8 produce

$$W(t+1)=W(t)+\mu[\gamma_1 \square_1+\gamma_2 \square_2] \quad (12)$$

The final weight vector upgradation equation of the MIR-LMS algorithm is estimated from equation 12.

IV. SIMULATION RESULTS AND DISCUSSION

For simulation of adaptive algorithm, MATLAB is used and array used is uniform linear array (ULA). In simulation we compare the MIR-LMS algorithm with other conventional algorithm with different ratio parameter

Case 1: Ratio parameters $\gamma_1 = 0$, $\gamma_2 = 1$, Step size $\mu = 0.08$, Number of element in array N=7, Desired angle $= 0^o$, Interference angle $= 40^o, -20^o$, iteration =100.

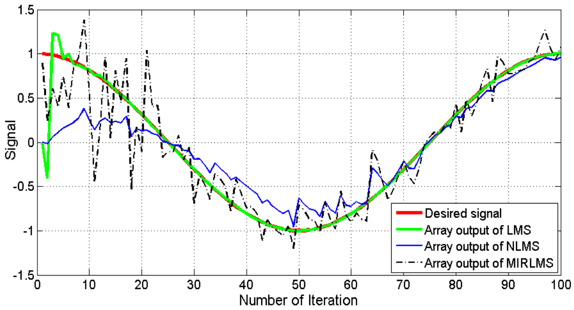
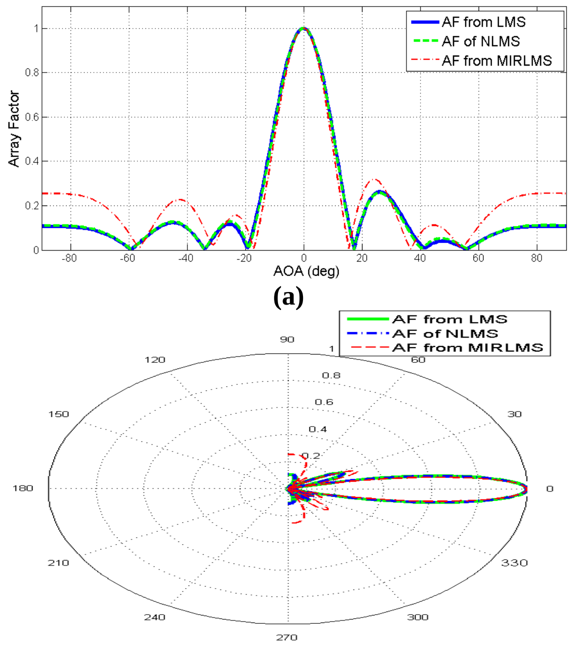


Figure 1 Signal response for ratio parameter γ_1=0 and γ_2=1



(a)

(b)

Figure 2 Beam forming capability of different algorithm with ratio parameter $\gamma_1 = 0$ and $\gamma_2 = 1$, AOA of desired user: 0^o and AOA of interference -20^o, 40^o

(a) Rectangular plot (b) polar plot

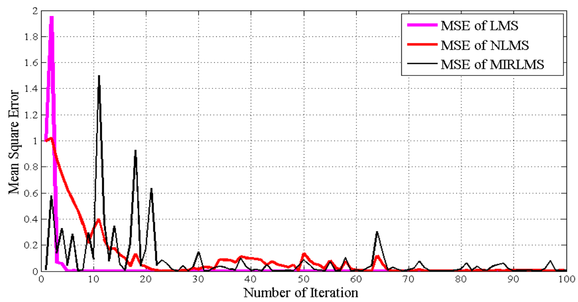


Figure 3 Mean Square Error for ratio parameter γ_1=0 and γ_2=1

When we consider only the previous normalized product vector (ratio parameter γ_1=0 and γ_2=1) for weight up gradation then we see that our signal response is very poor, in beam forming although it maximizes the beam towards desired user AOA but not fully nullify the interference AOA. In MSE convergence rate is fast but very high Brownian motion is there.

Case 2: Ratio parameters γ_1 = 1, γ_2= 0, Step size μ = 0.08, Number of element in array N=7, Desired angle = 0^o, Interference angle=40^o,-20^o, iteration =100.

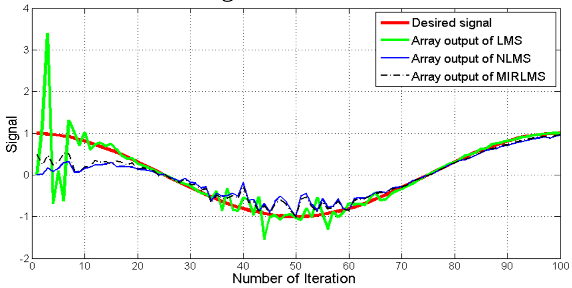
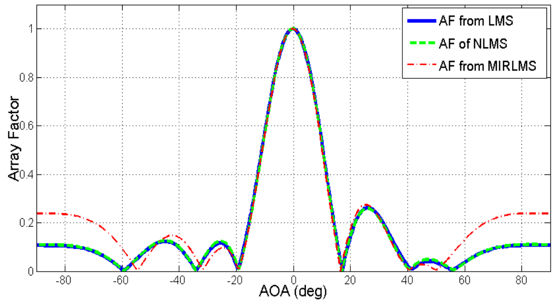
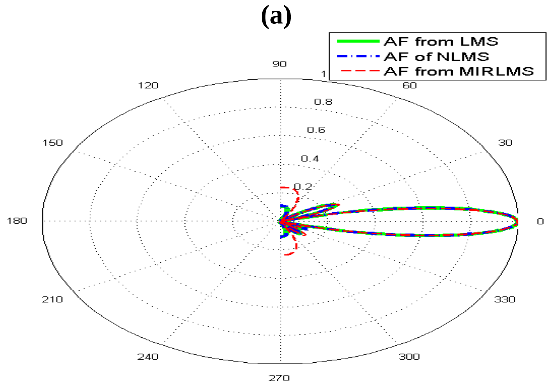


Figure 4 Signal response for ratio parameter γ_1=1 and γ_2=0



(a)



(b)

Figure 5 Beam forming capability of MIR-LMS for ratio parameter γ_1=1 and γ_2=0, AOA of desired user : 0^o and AOA of interference : -20^o , 40^o (a) Rectangular plot (b) polar plot

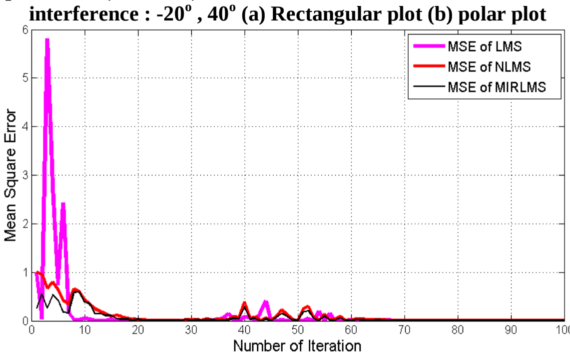


Figure 6 Mean Square Error for ratio parameter γ_1=1 and γ_2=0

When we consider only the present normalized product vector (ratio parameter γ_1=1 and γ_2=0) for weight up gradation then we see that our signal response is poorer than NLMS algorithm response and in the end follow NLMS response while beam forming capability is good it direct the beam towards desired user AOA and nullify the interference AOA. In MSE convergence rate is faster with less Brownian motion.

Case 3: Ratio parameters γ_1 =0.5 γ_2 =0.5, Step size μ = 0.08, Number of element in array N=7, Desired angle = 0^o, Interference angle=40^o,-20^o, iteration =100.

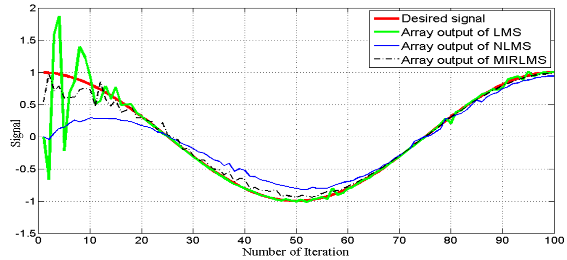
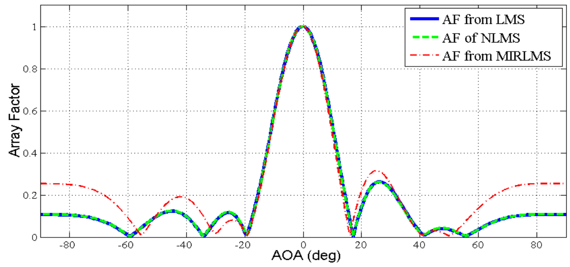
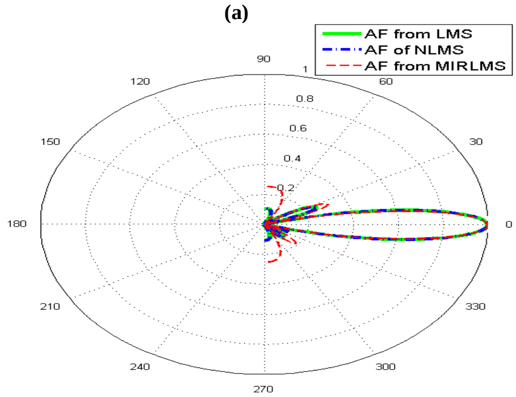


Figure 7 Signal response for ratio parameter γ_1=0.5 and γ_2=0.5



(a)



(b)

Figure 8 Beam forming capability of MIR-LMS for ratio parameter γ_1=0.5 and γ_2=0.5, AOA of desired user: 0^o and AOA of interference: 40^o,-20^o (a) Rectangular plot (b) Polar plot.

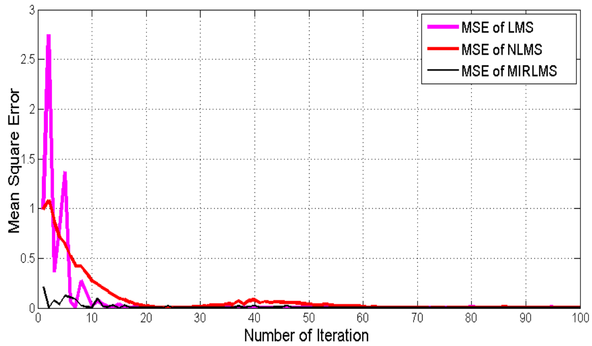


Figure 9 Mean Square Error for ratio parameter γ_1=0.5 and γ_2=0.5

When we give equal priority to both present and previous normalized product vectors (ratio parameter γ_1=0.5 and γ_2=0.5) than our signal response is improved as compared to NLMS algorithm, beam forming capability has improved and in MSE convergence rate fast Brownian motion is almost decreasing to zero.

CONCLUSION

In this paper, we implemented a new and effective array beamforming algorithm called Matrix Inverse Robust least Mean Square (MIR-LMS) algorithm which combines the individual good aspect of Sample Matrix Inversion (SMI), Normalize LMS (NLMS) and Robust LMS (R-LMS) algorithm. Were the convergence rate, signal response and beamforming capability of LMS, NLMS is compared with proposed MIR-LMS algorithm with different ratio parameter and fixed step size with the help of MATLAB simulator. It shows that the convergence rate and Signal response (Array output) was improved and also the weight is updated in such a way that it suppresses the interference and direct the beam towards the desired direction.

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