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Interference Suppression in Wireless Communications by Adaptive Beam Forming Algorithm and Windows

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Abstract: ***Smart antennas plays major role for improving the capacity and range, conventional methods like LMS (least mean square), Normalized LMS (NLMS) are not suitable for reducing the inferring signals, and the basic drawback of NLMS is variable step size at each iterations because of stable step size. In VSSNLMS algorithm method step size is variable and MSE should be reduced up to the desired level but it takes more processing time for the updation of tap weights. So in order to reduce the above short comings, For LMS algorithm,a new technique is developed for wireless systems. For steering the antenna beam electronically LMS algorithm is used .Sample-by-Sample adaptive implementation and Block-data of the MBER solution is done by using the Rectangular, Hamming, Kaiser, Chebyshev windows. Antenna Half power beam width is to the extent of using Matlab simulation by making use of window techniques. The system gain will increase the CDMA performance of the system. They offer a wide range of ways to increase performance of the wireless system.***

I. INTRODUCTION

DSP algorithm based antennas plays major role for increasing the throughput and extent. In communication systems the development the high data rates of modern mobile systems. Adaptive array antenna technology depends on many applications. They prioritize the necesity to enhance the extent and speed of wireless links and has also encouraged the interest in the deployment of used technologies. The most leading and popular advanced innovations of smart antennas proved themselves for obtaining the networks with higher efficiency whereas throughput, quality, and coverage are increased to the optimal. Conventional antennas provides low throughput and performance than smart antennas due to their use in customize & fine-tuned of the coverage of antenna configuration to change the radio frequency (RF) or condition of traffic in any no wire systems [1-3].

A DSP algorithm based antenna comprised of a ULA (uniform linear array) antennas by a mixture of complexive weight using an adaptive beam form algorithms which held in the base station of a mobile system.

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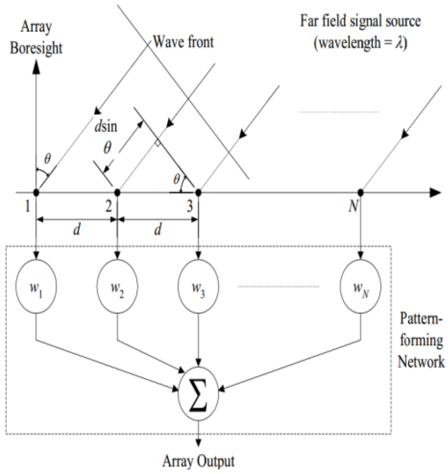

Figure1: Antenna pattern model

This research article demonstrates the drawbacks of VSSNLMS and NLMS and the proposal ALMS (Adaptive LMS) have better results when compared with VSSNLMS and all the other LMS-based algorithms in terms of interference suppression and half power beam width. The remaining paper illustrated as: In Section II presents the previous work for NLMS and VSSNLMS algorithms and mathematical analysis, whereas in section III, proposed method model and corresponding parameters Interference reduction and half power beam widths using different windows are illustrated and discussed in section IV analysis of MATLAB simulation results. Finally, the results and conclusions are discussed in section V.

II. RELATED WORK

This section comprise of above mentioned adaptive beam forming algorithms

A. NLMS Algorithm

The functionality of NLMS adaptation algorithm is given in Fig 2. Here $x(k)$ is for the i/p s/l and $y(k)$ is for the o/p s/l ie., the difference of the desire signal $d(k)$ to calculate the error s/l $e(k)$. $x(k)$ and $e(k)$ are joined in the NLMS algorithms that control the adaptive beam former behaviour to decrease the mean square error (MSE). That method should repeat no. of times til the fixed state is reached [8].

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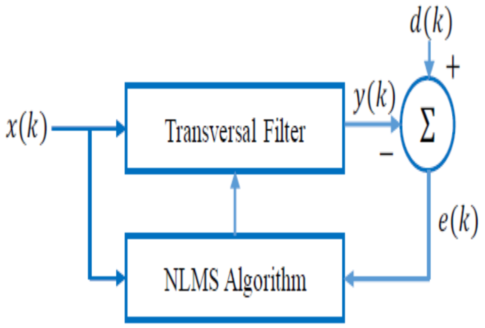

Fig 2:NLSM system model

The updated weight vector from above model is

$$\delta w(k+1) = w(k+1) - w(k). \qquad (1)$$

The desired response d(k) from the above figure is

$$d(k) = w^H(k+1)x(k). \qquad (2)$$

The error signal is represented as

$$e(k) = d(k) - w^H(k)x(k) \qquad (3)$$

The error can be rectified in NLMS using the below equation

$$w(k+1) = w(k) + \frac{\mu\, e(k)x(k)}{\sigma + \|x(k)\|^2}$$

(4)

But NLMS beam forming algorithm can be applicable for fixed step size, the mean square value is limited in this method, more over the interfering signal reduction is not at acceptable level

2. VSSNLMS Algorithm

The major point to be substitute the stable step size μ i.e., already in NLMS by constant 1 by the VSS NLMS algorithm. That is keep away a trade-off issue b/w convergence rate & steady-state MSE. In the algorithms a higher μ value is used in the starting stage to rate speed convergence and a small μ is used near to the fixed state of the Mean Square Error (MSE) to obtain an optimum value [9]. To achieve that, μ is multiplied by *P(k)* which is randomly choosed from the uniformly distributed [0 1] and at every time of the *N* iterations. The error can be reduced by the following equation,

$$w(k+1) = w(k) + \frac{\mu(k)\, e(k)x(k)}{\sigma + \|x(k)\|^2} \qquad (5)$$

Even though the convergence is faster with reduced MSE levels in VSSNLMS algorithm but this method required more processing time for the updation of tap weights .Maintain variable step size is a complexive case. In order to mitigate above drawbacks an adaptive low complexity LMS based algorithm with different window technique are used, these windowing techniques efficiently handles the processing time and variable step size problems along with the interference reduction

III. PROPOSED METHOD

A. Adaptive-LMS Algorithm and its Array pattren

Consider an antenna Array (ULA) with N isotropic elements, which is used to design the proposed system given in the fig.

The o/p of the array antennas is given by,

$$x(t) = s(t)a(\theta_0) + \sum_{i=1}^{N} u_i(t)\, a(\theta_i) + n(t) \qquad (5)$$

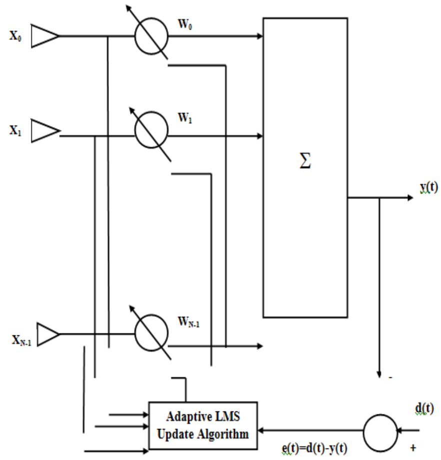

Fig 3 Proposed interfering reduction model

S(t) is the original s/l starting at the angle θ_0 and $U_i(t)$ denoted the interfering signal arrived at angle of incident θ_i respectively. $a(\theta_0)$ denotes the steering vector for the desired s/l and $a(\theta_i)$ represents the steering vectors for interfering s/l's respectively[3]. Hence, requires to construct the desired s/l's from the receiver s/l among the interfered s/l and the additional noise n(t). The o/p of the every single sensor is sequentially combined by following scale uses the equivalent weight so that the array pattern antenna optimizes to have nulls in thee interferers direction and to have max possible gain in the direction of the desired signal as shown above. The weight will be calculated using LMS(Least Mean Square) algorithm based on MSE (Minimum Squared Error) criterion. Hence, by minimizing the error between the reference signal d(t) and the spatial filtering problems which is involved by estimating the s/l s(t) from the received s/l x(t)(i.e. the array output), which matches nearly or has some extent of correlation with the beamformer o/p y(t) (equal to w x(t)) and the desired s/l estimate. By using the LMS algorithm, the solution can be iteratively found for classical Weiner filtering problem[2-4].

B Formulation of LMS algorithm

The weight vector equation is given from the method of steepest descent ,

$$w(n+1) = w(n) + \mu[-\nabla(E\{e^2(n)\})] \qquad (6)$$

Here μ is represented as the step-size parameter and it controls the convergence characteristics of the LMS(Least Mean Square) algorithm; $e^2(n)$ is represented by the mean square error between the reference signal and the beamformer output y(n) is given as,

$$e^2(n) = [d^*(n) - w^h x(n)]^2 \qquad (7)$$

The weight update equation can be determined as

$$\nabla_w(E\{e^2(n)\}) = -2r + 2Rw(n) \qquad (8)$$

The calculation involves to find the values R and r matrices in real time is the biggest problem in the steepest descent method.

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On the other hand the Least Mean S algorithm simplifies this by the instant values of the covariance matrices r and R instead of their actual values i.e.

$$R(n) = x(n)x^h(n)$$

$$r(n) = d^*(n)x(n)$$

Hence the updated weight can be represented as,

$$w(n+1) = w(n) + 2\mu x(n)[d^*(n) - x^h(n)w(n)]$$

$$= w(n) + 2\mu x(n)e^*(n) \qquad (9)$$

The Least Mean Square (LMS) algorithm is initiated with the vector weight at n=0 for the arbitrary value w(0). The following corrections of the vector weight eventually leads to the minimum value of the MSE(mean squared error)[9].

Hence, in following equations the LMS algorithm can be summarized

Output, $$y(n) = w^h x(n) \qquad (10)$$

Error,

$$e(n) = d^*(n) - y(n) \qquad (11)$$

Weight,

$$w(n+1) = w(n) + 2\mu x(n)e^*(n) \qquad (12)$$

C. Steps in A-LMS algorithm

The ALMS(Adaptive-Least Mean Square) algorithm accordingly proceeds to the following steps:

1. By placing all the tap filters to some of the casual values the weight vector is initialized. A common possibility is to place all the taps to zero.
2. One constant is taken. While it is a choice to determine for each particular problem the maximum theoretical value of that will give still guaranteed convergence, in practice, it is usually taken from the experience and it is reduced/improved if necessary.
3. e[k] and the vector X_K is combined from the i/p sample is calculated by
$$e[k] = d[k] - y[k] = d[k] - X_k^T W_k$$
4. Using the updated weight equation W_{K+1} is calculated.
5. Place k with k + 1 and return to the 3rd step.

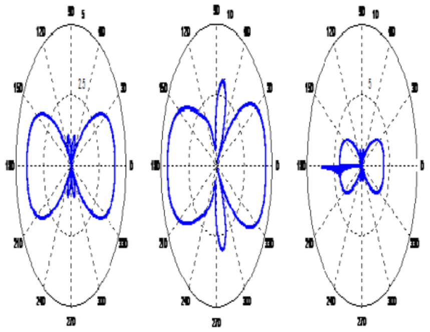
D. Importance of the window function:

The most common approach to reduce the side lobe levels is to multiply the weight vector with the window function, i.e rectangular window, Kaiser Window, hamming window, chebyshew window

The primary issue in choosing a window function *w(n)* is the tradeoff between frequency resolution and frequency leakage, that is, between main-lobe width and side lobe level. Ideally, one would like to meet, as best as possible, the two conflicting requirements of having a very narrow main lobe and very small side lobes.

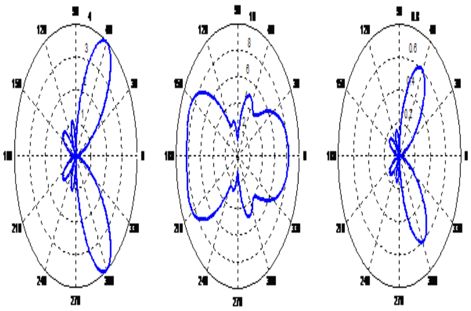
IV. RESULTS

The N=4 antenna elements with interfering signals arriving at angles θ_{i1}, θ_{i2} and θ_{i3} and desired angle θ_d is given below.

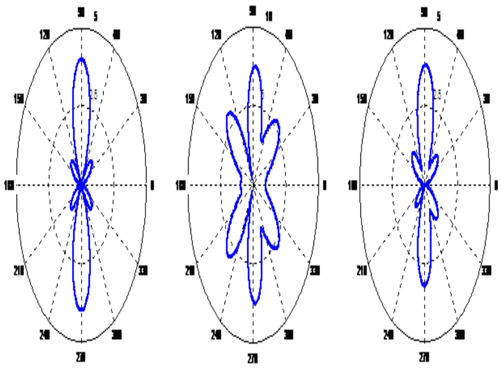


a)original signal b)original signal with interference c)LMS with original signal

Fig 4 –Rectangular array Polar plot with N=4, d=λ/2,
$\theta_d = 180^\circ, \theta_{i1} = 135^\circ, \theta_{i2} = 80^\circ$ and $\theta_{i3} = 20^\circ$



a)original signal b)original signal with interference c)LMS with original signal
Fig 5 –Hamming array Polar plot with d=λ/2, N=4
$\theta_d = 60^\circ, \theta_{i1} = 20^\circ, \theta_{i2} = 180^\circ$ and $\theta_{i3} = 135^\circ$



a)original signal b)original signal with interference c)LMS with original signal
Fig 6 - Chebyshev array Polar plot with d=λ/2, N=4,
$\theta_d = 90^\circ, \theta_{i1} = 45^\circ, \theta_{i2} = 75^\circ$ and $\theta_{i3} = 135^\circ$

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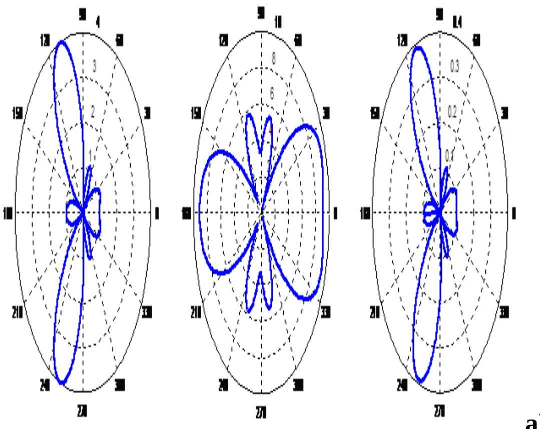

a)original signal b)original signal with interference c)LMS with original signal

Fig 7 – Kaiser array Polar plot with N=4, d=λ/2, $\theta_d = 110^\circ, \theta_{i1} = 20^\circ, \theta_{i2} = 85^\circ \text{ and } \theta_{i3} = 180^\circ$

COMPARISION OF MEAN SQUARE ERROR VALUE FOR DIFFERENT WINDOWS

The LMS algorithm tracks the desired signal. However, as the adaptation process continues, the weights are matched towards its o/p signal y(t) and the optimum follows the original transmitted S/L s(t) more similar with a small error.

The signal error is followed as

$$e[k] = d[k] - y[k]$$
$$= d[k] - X_K^T W_K \quad (13)$$

Here d[k] is the original s/l & y[k] is the o/p of the algorithm

Table 1-Error Values of Different Windows

S.No	Types of Windows	MSE
I	Rectangular window	-0.00580
II	Hamming window	-0.00050
III	Chebyshev window	0.00370
IV	Kaiser window	-0.0030

V. CONCLUSIONS

All the signals transmitted turned to the factors for all the other system users in the form of interference in a CDMA system. Hence, strong system capacity is depending on the system level interference . Therefore in the case of CDMA systems, our suggested method shall control interference by creating5- low side lobe towards the un desired users and the main lobe towards desired user . It have been discovered that the window function role is absolutely compute the complexity and impressive of the effort associated with its application in managing the side lobes. This method furnishes that Chebyshew window can be flexible to achieve narrow beam towards desire user and decrease the maximum side lobe level when compared with other fixed side and adjustable lobe windows yielded. Hence by using Chebyshew window the system gain and as well as performance should be increased. Even though the convergence is faster with reduced MSE levels in VSSNLMS algorithm but this method requires more processing time for the updation of tap weights .Maintain variable step size is a complex case. In order to mitigate above drawbacks an adaptive low complexity LMS based algorithm with different window technique are used, these windowing techniques efficiently handles the processing time and variable step size problems along with the interference reduction

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