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DRLMS Adaptive Beamforming Algorithm for Smart Antenna System

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Abstract

Smart antenna system is very useful to increase the capacity, coverage and quality of communication system. Smart antenna combines the antenna array with digital signal processing capability with tracks the mobile user continuously by steering the main beam towards the desired user and at the same time forming null in the direction of interfering signal. This paper presents the performance analysis of Data reusing least mean square (DRLMS) and Least Mean Square (LMS) through beam steering ability and nullifying capability of algorithm and comparative analysis is done using MATLAB 7.14.The simulation result shows that DRLMS has better performance and interference suppression capability, beam steering ability and higher convergence rate than LMS.

Keywords: Smart Antenna, Adaptive Algorithm, Beamforming, Convergence rate, DRLMS, LMS.

INTRODUCTION

Reliable wireless communication system demands for higher data rates with better coverage and high quality of service as there is an explosive growth in the number of users. This can be achieved by spatial filtering. Smart antenna system is one of the most promising technology that uses spatial filtering process that will provide the solution to enhance system capacity, better coverage, higher spectrum efficiency, improved quality of service reduced power consumption by effectively reducing multipath and co-channel interference [1]. Smart antenna is defined as an array of antennas with digital signal processing unit that can change its beam pattern automatically towards a desired user and place null in the direction of noise, interference and multipath signals [2]. Smart antenna system can be classify as either switched beam or adaptive array system.

In switched beam system users in the desired direction are served by multiple fixed beam [3].Because the beams are fixed, so as the mobile user changes its position through the cell its signal strength varies. The base station determines the beam that is best aligned in the signal of interest direction by switching between several fixed beams to communicate with the user [4]. Adaptive array system uses antenna array with signal processing capability to automatically change the beam pattern in accordance with the changing RF environment where both desired signal and interfering signal location changes. It has ability to effectively track and locate various types of signal as desired signal, multipath or interfering signal and distinguish them and it also calculate their direction of arrival. Adaptive array not only directs the maximum radiation in the direction of desired signal but also introduces null at the interfering signal direction. This can be achieved by varying the complex weights of each of antenna used in the array by beamforming algorithm. Weights are complex in nature and adjust the amplitude and phase of signal. The adaptation process [5] is achieved by multiplying the incoming signal with weights and then summing them together to obtain the desired beam pattern.

Adaptive beamforming is defined as the process of adapting magnitude and phase of the signal by adjusting the complex weight of every antenna element with respect to time .The phase and amplitude are adjusted to optimize the received signal [6], this causes the output of the antenna array to form or receive in a particular direction and minimizes the output in other direction .The complex weights are iteratively computed using adaptive algorithm based upon different criteria. The performance criteria could be minimizing he mean square error, maximum signal to interference and noise ratio, maximum likelihood, minimum noise variance [3].

ADAPTIVE BEAMFORMING

Beamforming or spatial filtering is the process of combining the signal then focusing the radiation in a particular direction. It is the technique in which an array of antenna exploited to achieve maximum reception in desired direction and rejecting signal of same frequency in other direction .This can be accomplished by phasing the feed to each element of an array so that the signal received or transmitted from all element are in phase in a particular direction[7],[3] .The phase and amplitude are adjusted to optimize the received signal, adaptive algorithms are employed to adjust the weights and hence minimize the mean square error between desired signal and array output.

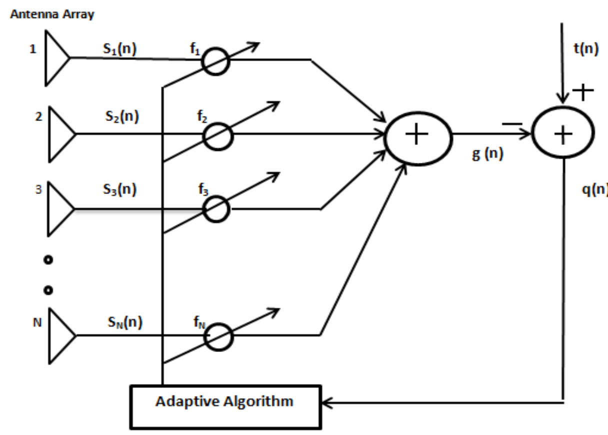

Figure 1. Block diagram for Adaptive Beamforming Network

Fig.1 shows the smart antenna system consists of uniform linear array with N antenna element that are linearly spaced. The signal s(n) received by multiple antenna element is multiplied with the coefficients in the weight vector(series of amplitude and phase coefficients)which adjust the phase and amplitude of incoming signal and the weighted signal is summed up resulted in the array output g(n). The output of an array is the weighted sum of the received signal s(n) at the antenna element and the array weight f(n). An adaptive algorithm is then employed to minimize the error q(n) between a desired signal t(n) and array output g(n).

The output response of uniform linear array is given as,

$g(n)= f^{H}s(n)$

Where, $s(n) =[s_1(n)\dots s_N(n)]$

$f=[f_1\dots f_N]^H$

Where H denotes Hermitian complex conjugate transpose and f is the complex weight vector. The process of adjusting these weights $f_1\dots f_N$ adjust the amplitude and phase of signal such that the output of an antenna array to form or receive in a particular direction and minimize the output in other direction.

BEAM-FORMING ALGORITHMS

The adaptive algorithm is derived by defining the performance criteria which are being implemented by a set of iterative equation to adjust the weight so that the performance criterion is achieved. The performance criteria could be minimum mean square error [8]. The main aim of adaptive beamforming algorithm is to form multiple beam towards desired user while nulling to the interference at the same time through the adjustment of the weight vector. This can be achieved by observing the error between the array output and desired signal .An adaptive algorithm updates the weights vector with the aim to minimize an objective function .It is not the antenna that is smart, the availability of adaptive beamforming algorithm makes the antenna to be smart and gives intelligence to it [6]. There are two types of adaptive algorithm are Blind and Non blind algorithm. Non blind adaptive algorithm require the statistical knowledge of the transmitted signal in order to converge to a weight solution [9], this can be achieved by using a pilot signal or reference signal to detect the desired signal and updates the complex weight .Non blind based adaptive algorithm are based on minimization of mean square error between received signal and reference signal. Blind adaptive algorithm does not need a pilot signal or reference signal to update the complex weight [3].

Therefore this piece of work explore the performance of non-blind adaptive beamforming algorithms as LMS (Least mean square) and DRLMS (Data reuse least mean square) for smart antenna system.

(a) Least Mean Square Algorithm

Least mean square (LMS) algorithm, was introduced by Windrow and Hoff in 1959 [10],[3], is an adaptive algorithm which uses a gradient based method of steepest decent [7]. LMS algorithm uses the estimates of the gradient vector from the available data and follows iterative procedure for weight vector calculation in the direction of the negative of the gradient vector which leads to minimum square error [10]. The LMS algorithm can be described by the following three equations as,

$g(n)=f^H(n).s(n)$

$q(n)=t(n)-g(n)$

$f(n+1)=f(n)+\Delta*s(n)*q(n)$

Where,

g(n)=array output

s(n)=input data vector

t(n)=reference signal

f(n)=weight vector

q(n)=error signal

Δ=step size

Convergence and stability of LMS algorithms is controlled by the step size parameter μ and have value

$$0< \Delta< 1/\lambda_{max}$$

Where λ_{max} is the largest eigen value of correlation matrix M .where $M=E[s\ s^H]$ The convergence rate of the algorithm is inversely proportional to the eigen value spread of the correlation matrix M. when the eigen value of M are widespread convergence rate is slow and large value of step size Δ leads to faster convergence but stability around minimum value will be lost [11].

(b) Data Reuse Least Mean Square Algorithm

Data Reuse Least mean square (DRLMS) is an non blind adaptive algorithm which uses current desired and input signal as repeatedly within each iteration in order to obtain better estimate of the coefficients .DRLMS algorithm aim to improve the convergence rate by reusing the same set of data (i.e. the input and reference signal) several time .DRLMS adaptive algorithm reuses the same set of data(s (n) input and t(n) desired) L time in same time index n.

DRLMS algorithm with L data reuse, the coefficient are updated as given by following equations,

$g(n)=f_i^T(n)s(n)$

$q_i(n)=t(n)-f_i^T(n)s(n)$

$i=1, 2\dots\dots L$

$f_{i+1}(n)=f_i(n)+\Delta*q_i(n)*s(n)$

$f_1(n)=f(n),$

$f(n+1)=f_{L+1}(n)$

Where,

g(n)=array output

s(n)=input data vector

t(n)=desired signal

$f_i(n)$=weight vector at i^{th} data reuse

$q_i(n)$=output error at i^{th} data reuse

For L=1, the DRLMS (Data reuse least mean square) algorithm is equivalent to LMS (Least mean square) algorithm

SIMULATION AND RESULTS

The performances of least mean square (LMS) and Data reusing least mean square (DRLMS) adaptive beamforming algorithms are evaluated and compared through beam pattern and for the simulation purpose the uniform linear array of 4 element with half wavelength spacing between the element is considered .Two interfering and one desired signal is taken, the desired user is arriving at an angle 30 degrees and interferer signal are at 0 degree and 60 degrees, step size parameter value is equal to 0.05 is considered.

Figure.2and figure.3 represents the beam pattern plot and polar plot of DRLMS and LMS algorithm respectively.

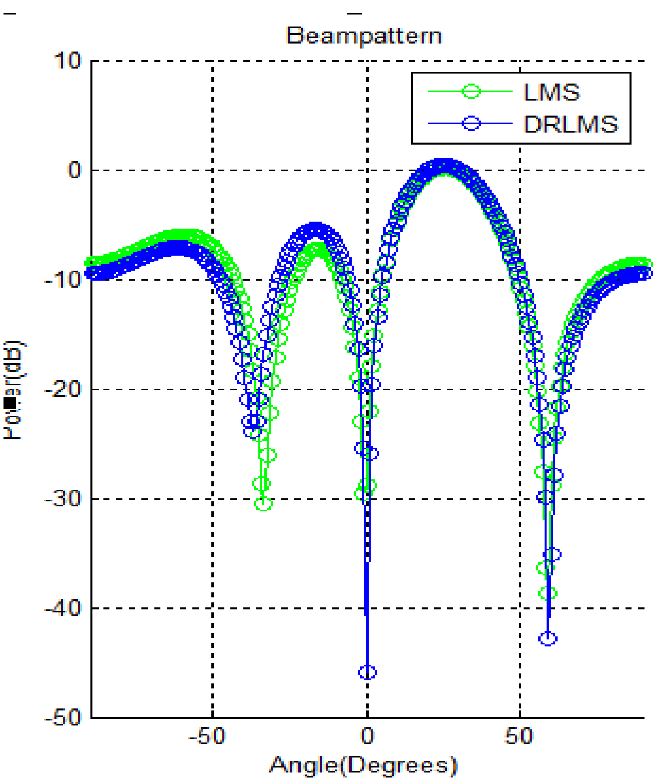

Figure 2. Comparison Beam Pattern plot of DRLMS and LMS algorithms

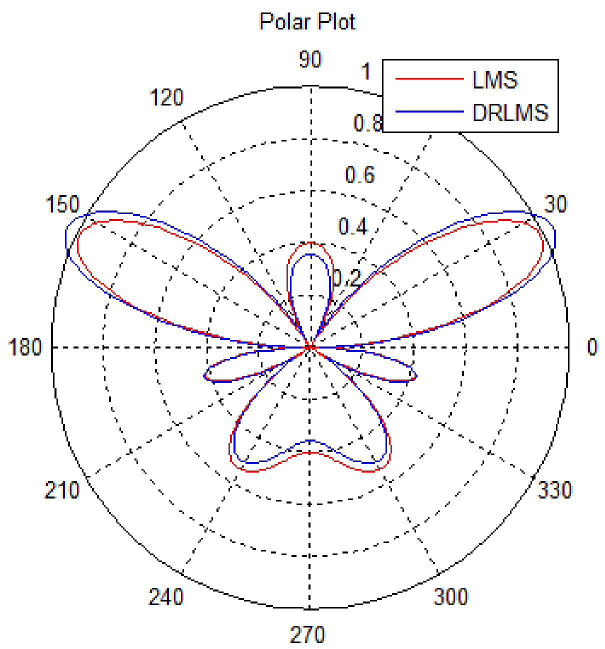

Figure 3. Comparison polar plot of DRLMS and LMS algorithms

From the figure.2 it can be seen that both the algorithm directs the main beam towards the desired signal direction at 30^0 and null towards the interfering directions. LMS algorithm has null depth of -30db at 0^0 towards the first interferer and -40db at 60^0 towards the second interferer. DRLMS algorithm places nulls towards both the interferer with null depth of -47db at 0^0 and -44db at 60^0.Simulated result shows that the DRLMS algorithm provides fast convergence than LMS algorithm by increasing main lobe power and deep null towards the interference hence DRLMS significantly reduces the interference level and improves the system performance.

CONCLUSION

This paper evaluates the performance of least mean square (LMS) and data reuse least mean square (DRLMS) beamforming algorithms for Smart antenna system. It has been shown that both the algorithm direct the main beam towards the desired signal direction but the performance of LMS is unsatisfactory to nullify the interference as compared to DRLMS algorithm and it also encountered with the limitation of slow convergence rate. So the DRLMS adaptive algorithm has been proposed which can offers faster convergence rate by reutilizing available input and reference signal repeatedly in each iteration .From simulated result it can be seen that DRLMS algorithm direct the beam towards the desired direction with increased gain and places null towards interferer, which can maximizes reception of desired signal by nulling the interfering signal and hence two signal of same frequency separated out in spatial domain which improves the capacity and performance of system

REFERENCES

[1] M.Kamaraju, K.Ramakrishma, K.Ramanjaneyulu, "A Novel Adaptive Beamforming RLMS Algorithm for Smart Antenna System", International journal of Computer Applications, vol.86, No.5.pp.27-32January 2015.

[2] Edvin J. Kitindi,,"Capabilities of smart antenna in tracking the desired signal in wireless communication system through non blind adaptive algorithm", International Journal of Advanced Research in computer and communication Engineering,vol.4,issue2 ,February 2015

[3] Shaikh, Panda D.K, "Linear, Non -Linear Adaptive Beamforming Algorithm for Smart Antenna System", International conference of computer communication and control, IEEE 2015

[4] Abdul Aziz, M.Ali Qureshi, Junaid Iqbal "Performance and Quality Analysis of Adaptive Beamforming Algorithms (LMS, CMA, RLS, CGM) for Smart Antennas", International Conference on Computer and Electrical Engineering, Vol. 6, pp. 302-306, 2010.

[5] Saima Shaikh, D.K, Panda "Performance Analysis of LMS, DFE-LMS Adaptive Beamforming Algorithm for Smart Antenna System", Far East Journal of Electronics and Communication, Volume16, no.1, January 2016.

[6] GC Nwalozie, V.N. Korogu, S.S Maduadichie, A.Adenol, "A Simple Comparative Evaluation of Adaptive Beamforming Algorithm", International Journal of Engineering and Innovative Technology vol.2, issue7, January 2013.

[7] N.Kannan, Aneesha Rose Raju, S.Sasikala, "Assessment of Adaptive Beamforming Algorithm for Uniform Linear Array", International Journal of Review in Electronics and Communication Engineering, vol.2.issue1, February 2014.

[8] Satgur Singh, Man deep Kaur, "LMS and NLMS Algorithm Analysis for Smart Antenna", International Journal of Advanced Research in computer Science and Software Engineering, vol.5pp.380-384, issue4,2015.

[9] Ravati Joshi, Ashwini Kumar Dander, "Adaptive Beamforming Using LMS Algorithm", International Journal of Research in Engineering and Technology vol.03, issue 05,May2014.

[10] Surya Mubeen, A. Prasad. A.Jhansi Rani, "Smart Antenna Its Algorithm And implementation", International Journal of Advanced Research in computer Science and Software Engineering, vol.2pp.97-101, issue4, 2012.

[11] Ch.Santhi Rani, P.V.Subhaiah, K.chennakesava, "LMS and RLS Algorithm for Smart antenna system in W-CDMA Communication Environment", ARPN Journal of Engineering and Applied Science, vol.4, No.6 pp.897-901,August 2009.

[12] Somnath Patra, "Power pattern synthesis of smart antenna array using different adaptive algorithm", International Journal of Advanced Research, vol.3, pp.1459-1466, May 2015..

[13] M.Kamaraju, K.Ramakrishma, K.Ramanjaneyulu, "A Novel Adaptive Beamforming RLMS Algorithm for Smart Antenna System", International journal of Computer Applications, vol.86, No.5.pp.27-32January 2015.

[14] Frank Gross, "Smart Antenna for Wireless Communication" McGraw-Hill, September 14, 2005

[15] P. S. R. Diniz, Adaptive Filtering: Algorithms and Practical Implementation. 3rd edition Springer, New York, NY, USA (2008).

[16] L.C.Godara,Application of Antenna array to Mobile Communication,Part.II.Beamforming and Direction Of Arrival Consideration, Proceeding of IEEE 85(8) 1195-1245 August.