A NOVEL STUDY OF NEW ADAPTIVE BEAMFORMING ALGORITHM FOR SMART ANTENNA

AVANISH YADAV[1], DIVYANSHU RAO[2], RAVI MOHAN[3]

1- Dept of ECE, ME student, SRIT, JABALPUR, M.P., INDIA

2-Dept of ECE, Prof., SRIT, JABALPUR, M.P., INDIA

3- Dept of ECE,Prof., SRIT, JABALPUR, M.P., INDIA

ABSTRACT: The smart antennas are widely used for wireless communication; because it has ability to increase the coverage, reduce the interference & increase the capacity of a communication system. A Smart antenna system is used to maximize the output power of signal in desired direction and minimize the power in unwanted direction. Smart antenna system consists of multiple numbers of elements. Using beam forming algorithm smart antenna is able to form main beam towards desired user and null in the direction of interfering signals. The search on efficient methods is still a valid challenge. In this paper we studied and analyzed different beam forming methods. During survey of work we have found that different authors have developed separate methods to solve the purpose. So we conclude that there is not any unique method in this regard. Hence in this work we come across to develop a new adaptive beam forming algorithm for smart antenna to solve the purpose using MATLAB.

KEYWORDS: Smart Antenna, NLMS, LMS, MI-NLMS, MUSIC, Beam forming, convergence speed.

I. INTRODUCTION

A smart antenna system is a multi-element antenna where the signals received at each antenna element are intelligently combined to improve the performance of the wireless system. Smart antennas can increase signal range, reduce signal fading, suppress interfering signals, and increase the capacity of wireless systems [5]. A smart antenna system consists of an array of antennas that together directs different transmission or reception beams towards each user in the antenna system. This method is called beam forming which is a signal processing technique used in sensor arrays for directional signal transmission or reception of signal [6].

Adaptive Beamforming is a technique in which an array of antennas is exploited to achieve maximum reception in a specified direction by estimating the arrival of signal from a desired direction (in the presence of noise) while signals of the same frequency from other directions are rejected. This is achieved by varying the weights of each of the sensors (antennas) used in the array [7].

II. LITERATURE REVIEW

Satgur Singh et.al suggested: "A LMS and NLMS Algorithm Analysis for Smart Antenna". The smart antenna plays an important role to reduce the interference in communication environment. Smart antenna can place nulls in the direction of interference via adaptive updating of weights linked to each antenna element. Smart antenna cancels out the co-channel interference resulting in better quality of reception and reduces the no. of dropped calls. In this paper, we analyze the performance of smart antenna system on LMS and NLMS algorithm and comparative analysis is done using MATLAB [1].

Arun Kumar Singh et.al: "Beamforming Showing Effect on BER with Change in Antenna Configuration". This work investigates the improvement in Bit Error Rate (BER) with different antenna configuration using beamforming technique. In this paper Linearly Constrained Minimum Variance (LCMV) beamforming is used and based on this BER graph is plotted. The idea is to show improvement in BER performance with increasing number of antenna and also to show that the data rate can be increased if BER is brought to a lower value [2].

A.Arunitha et.al suggested : "Adaptive Beam Forming Algorithms for MIMO Antenna" This paper discuss about Non-blind beam forming algorithm i.e. Least Mean Square and Blind beam forming algorithm i.e. Constant Modulus Algorithm and Sample Matrix Inversion. The algorithms are simulated for MIMO environment by using MATLAB. Beam forming can be used for either radio or sound waves. It has found numerous applications in radar, sonar, seismology, wireless communication, radio astronomy, speech and biomedicine [3].

Ashwini Deshmukh et.al suggested: "Survey Paper on Adaptive Beamforming LMS, NLMS and RLS Algorithms for Smart Antenna System". LMS algorithm is widely used in adaptive filter due to its relative low computational complexity, good stability and relatively good robustness against the implementation errors. To improve the convergence rate NLMS algorithm is used. LMS algorithm having constant step size but in NLMS algorithm step size is depends on data at each iteration. Whereas RLS algorithm having minimum bit error rate but it required more computations than the LSM algorithm [4].

Prerna Saxena, et.al suggested : "Performance Analysis of Adaptive Beamforming Algorithms for Smart Antennas". Adaptive beamforming techniques for smart antennas based upon Least Mean Squares (LMS), Sample Matrix Inversion (SMI), Recursive Least Squares (RLS) and Conjugate Gradient Method (CGM) are discussed and analyzed. The beamforming performance is studied by varying the element spacing and the number of antenna array elements for each algorithm. These four algorithms are compared for their rate of convergence, beamforming and null steering performance (beamwidth, null depths and maximum side lobe level) [5].

Minal. A. Nemade et.al suggested: "Analysis of LMS and NLMS Adaptive Beamforming Algorithms". Adaptive beamforming is technique in which array of antennas is exploited to achieve maximum reception in specific direction. An algorithm with small complexity, low computation cost, good convergence rate usually preferred. Step size is main parameter for both algorithm. In this paper, two non-blind algorithms: Least Mean Square (LMS) and Normalized Least Mean Square (NLMS) algorithms are discussed and results for both are shown [6].

Balasem. S.S et.al suggested: "Beamforming Algorithms Technique by Using MVDR and LCMV". In this paper Author's presents the significance of the beamforming technique employed for the next generation broadband wireless mobile systems. The capacity, data rates, null steering and coverage of the cellular system are improved by using various beamforming techniques such as the Minimum variance distortionless response (MVDR) and Linear constraint minimum variance (LCMV). These two techniques depend on the received weight vector of the desired signal. The simulation result shows that for all the improved system parameters the MVDR technique shows better results than LCMV technique [7].

Arti M.K., Student Member, IEEE et.al suggested: "Beamforming and Combining in Hybrid Satellite-Terrestrial Cooperative Systems". In this paper, authors consider the transmission of signals in a hybrid satellite-terrestrial cooperative system. In particular, we address the problem of beamforming and combining based amplify-and-forward (AF) relaying in a hybrid satelliteterrestrial cooperative system. In this set-up, a multiple antenna based relay node forwards the received satellite signals to the destination, by using a

beamforming vector, and multiple antenna based destination node uses maximal ratio combining. The approximate average symbol error rate of the considered beamforming and combining based hybrid AF cooperative scheme for *M*-ary phase shift keying constellation is derived; analytical diversity order of the hybrid system is also obtained. Moreover, diversity calculations for some specific antenna configurations are shown for providing useful insight of the proposed scheme, at high signal-to-noise ratio [8].

Thamer M. Jamel suggested: "Performance Enhancement of Smart Antennas Algorithms for Mobile Communications System". Author proposes new two smart antennas algorithms based on a combined method for performance enhancement of mobile communications systems. The first proposal combination method includes merging pure Conjugate Gradient Method (CGM) with pure Normalized Least Mean Square (NLMS) algorithms, so that the new algorithm is called as CGM-NLMS. While the second proposed algorithm will merge pure CGM with Modified NLMS algorithm so that this algorithm is called as CGMMNLMS algorithm. The two new proposed algorithms provides fast convergence time, higher interference suppression capability and low level of Mean Square coefficients Deviation (MSD) and minimum Mean Square Error (MSE) at the steady state compared with the pure CGM and pure NLMS algorithms [9].

Ali Hakam et.all suggested*: "*Robust Interference Suppression Using a New LMS Based Adaptive Beamforming Algorithm". Author's introduces a robust variable step size NLMS algorithm to improve interference suppression in smart antenna system. This algorithm is able to resolve signals arriving from narrowband sources propagating plane waves close to the array endfire. The results of the fixed step size NLMS will result in a trade-off issue between convergence rate and steady-state MSE of NLMS algorithm. This issue is solved by changing the step size from constant to variable. The proposed VSSNLMS algorithm reduces the mean square error (MSE) and shows faster convergence rate when compared to the conventional NLMS [10].

Kapil Dungriyal et.al suggested : " Performance of MIR-LMS algorithm for adaptive beam forming in Smart Antenna" .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) [11].

AMARA PRAKASA RAO et.al suggested : "Adaptive Beamforming Algorithms for Smart Antenna Systems" In this paper, Various evolutionary algorithms are used to adapt the weights of the smart antenna arrays to maximise the output power of the signal in desired direction and minimise the power in the unwanted direction. Numerical results are presented to verify the improved convergence of the algorithms. In Least Mean Square algorithm, the convergence speed of the algorithm depends on the step size, This problem is solved by normalised least mean square and recursive least square algorithms. Simulation results show that the better adaptive beamforming algorithms for smart antenna systems in mobile communications [12].

B. S. Reddy et.al suggested: "Adaptive Digital Beam Forming using LMS Algorithm". In this paper Nested LMS algorithms are used to optimize the radiation pattern. By varying the step-size, optimizing weights radiation patterns are observed. Change of direction of desired signal is also considered. It is observed that Gain is maximum in desired direction and nulls are created in the direction of noise signals [13].

Nu Nu Yi et.al suggested: "Modeling and Simulation of Adaptive Beamforming for Mobile Communication" In this paper performance of two beamforming algorithms namely MVDR and LCMV beamforming are compared. Beamformer to retrieve the signal from a particular direction using a ULA or a URA antenna are illustrated. MVDR beamforming requires only desired user direction. The choice of the beamformer depends on the operating environment. When the knowledge about the target direction is not accurate, the LCMV beamformer is preferable because it prevents signal self-nulling [14].

Revati Joshi et.al suggested: "Adaptive Beamforming Using LMS Algorithm". This paper evaluate the performance of LMS (Least Mean Square) beamforming algorithm in the form of normalized array factor (NAF) and mean square error(MSE) by varying the number of elements in the array and the placing between the sensor elements. The simulations are carried out using MATLAB [15].

Smita Banerjee et.al suggested: "An LMS Adaptive Antenna Array". In this paper non-blind adaptive beamforming algorithm LMS have been analyzed on a adaptive antenna system for three different cases. The performance of the algorithm is evaluated through radiation pattern. The results illustrate the fact the LMS algorithm is able to iteratively update the weights to force deep nulls at the direction of the interferers and achieve maximum in the direction of the desired signal. It can be summarized that in satellite communication system, beam of adaptive antenna array can be steered in the direction of user and can suppress the interference by LMS beamforming algorithm [16].

D. M. Motiur Rahaman et.al suggested: "Least Mean Square (LMS) for Smart Antenna" Author's analyzed the performance of adaptive LMS algorithm for smart antenna systems which very important for smart antenna design. The performance of LMS algorithm is compared on the basis of normalized array factor and mean square error (MSE) for SA systems. It is observed that an LMS algorithm is converging after 50 iteration. The attractive quality of LMS algorithm is less computational complexity [17].

Omar Mehanna, et.al suggested: "Joint Multicast Beamforming and Antenna Selection" Multicast beamforming exploits subscriber channel state information at the base station to steer the transmission power towards the subscribers, while minimizing interference to other users and systems. Such functionality has been provisioned in the long-term evolution (LTE) enhanced multimedia broadcast multicast service (EMBMS). As antennas become smaller and cheaper relative to up-conversion chains, transmit antenna selection at the base station becomes increasingly appealing in this context. This paper addresses the problem of joint multicast beamforming and antenna selection for multiple co-channel multicast groups. The objective
is to select sparse beamforming vectors such that the transmission power is minimized[18].

D. B. Salunke et.al suggested: **"**Analysis of LMS, NLMS and MUSIC Algorithms for Adaptive Array Antenna System**"** This paper presents the performance analysis of the popular algorithm using Matlab. LMS algorithm has good response towards desired direction and has better capability to place null towards interferer than NLMS. But the convergence speeds of NLMS algorithm is good than LMS. Sharper peaks in the MUSIC angular spectrum indicate locations of desired users. Peaks of LMS are formed in the same desired direction and deep null in the direction of the undesired interference [19].

L. Surendra et.al suggested: "Performance Comparison of LMS, SMI and RLS Adaptive Beamforming Algorithms for Smart Antennas". In this paper, LMS (Least Mean Square),SMI(Sample Matrix Inversion) and RLS(Recursive Least Square) adaptive beamforming algorithms are implemented in matlab for N=20 elements and d=0.5 From the results it is observed by increasing array elements improves the directivity in desired direction. The convergence of the LMS algorithm is directly proportional to the step size parameter μ. In comparison with LMS had more side lobes compared to SMI and RLS. RLS had more sidelobes compared to SMI [20].

Koteswara rao.Thokala et.al suggested: "Steering an Adaptive Antenna Array by LMS NLMS and BBNLMS Algorithms". In order to improve the convergence rate of LMS algorithm in smart antenna system, this paper proposes the Block Based Normalized LMS (BBNLMS) algorithm. The performance of the BNLMS algorithm in the presence of Multipath effects and multiple users is analyzed using MATLAB simulations. Simulation results confirm that the convergence rate and error reduction of BBNLMS is superior to conventional LMS algorithm [21].

Usha Mallaparapu et.al suggested: "Non-Blind Adaptive Beam Forming Algorithms for Smart Antennas". The analysis of LMS and NLMS is done using eight antennas with half wavelength spacing. LMS algorithm is less stable as variation of weight values is more. LMS algorithm shows output with more fluctuations. While in case of NLMS number of iterations needed for errors to converge is less. So convergence takes more time in the case of LMS than NLMS. The error convergence is more stable and shows quick convergence for NLMS algorithm [22].

Jalal Abdulsayed Srar et.al suggested: "Adaptive Array Beamforming Using a Combined LMS-LMS Algorithm". A new adaptive algorithm, called least mean square least mean square (LLMS) algorithm, which employs an array image factor, , sandwiched in between two least mean square (LMS) algorithm sections, is proposed for different applications of array beamforming. Computer simulation results show that LLMS algorithm is superior in convergence performance over earlier LMS based algorithms, and is quite insensitive to variations in input signal-to-noise ratio and actual step size values used [23].

Raed M. Shubair et.al suggested: "A Setup for the Evaluation of MUSIC and LMS Algorithms for a Smart Antenna System" This paper presents practical design of a smart antenna system based on direction-of-arrival estimation and adaptive beamforming. Direction-of-arrival (DOA) estimation is based on the MUSIC algorithm for identifying the directions of the source signals incident on the sensor array comprising the smart antenna system. Adaptive beamforming is achieved using the LMS algorithm for directing the main beam towards the desired source signals and generating deep nulls in the directions of interfering signals [24].

MOHAMMAD Tariqul Islam et.al suggested: "MI-NLMS adaptive beamforming algorithm for smart antenna system applications" A Matrix Inversion Normalized Least Mean Square (MI-NLMS) adaptive beamforming algorithm was developed for smart antenna application. The MI-NLMS which combined the individual good aspects of Sample Matrix Inversion (SMI) and the Normalized Least Mean Square (NLMS) algorithms is described. Simulation results showed that the less complexity MI-NLMS yields 15 dB improvements in interference suppression and 5 dB gain enhancement over LMS algorithm, converges from the initial iteration and achieves 24% BER improvements [25].

III. PROBLEM FORMULATION

After studying different approaches we observe that some of the algorithms provide fast convergence time, higher interference suppression capability and minimum Mean Square Error (MSE), but still there is need of an approach which may provide better result i.e. reduces the mean square error (MSE) and shows faster convergence rate as compared to the conventional algorithm.

IV. PROPOSED WORK

After analyzing several techniques we proposed a new Adaptive beamforming algorithm technique to reduce the mean square error (MSE), higher interference suppression capability and shows faster convergence rate for Smart Antenna system.

V. CONCLUSION

In this paper we present a survey on Adaptive Beamforming Algorithm for smart antenna system concentrating on different Adaptive techniques and emphasize on the problems, we also suggest an efficient solution to solve the above problem.

LMS algorithm is the most popular adaptive algorithm because of its low computational complexity. However, it suffers from slow and data dependent convergence behavior. NLMS is a variant of LMS that requires additional computation but offers superior performance.

If we are moving to the some combined algorithms provides better results i.e. LLMS algorithm is superior in convergence performance over earlier LMS based algorithms. MI-NLMS combines the SMI and NLMS algorithms to improve the convergence speed with small BER. MMSE (minimum mean square error), superior in convergence performance & small BER (bit error rate) are the performance parameter.

VI. REFERENCES

1. Satgur Singh & Er. Mandeep Kaur : " International Journal of Advanced Research in Computer Science and Software Engineering" Volume 5, Issue 4, 2015 page no. 380-384.
2. Arun Kumar Singh et.al: " Beamforming Showing Effect on BER with Change in Antenna Configuration" International Journal of Computer Applications Volume 112 – No. 6, February 2015 page no. 20-23.
3. A. Arunitha et.al: "Adaptive Beam Forming Algorithms for MIMO Antenna" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-4 Issue-8, January 2015 page no. 9-12.
4. Ashwini Deshmukh et.al : " Survey Paper on Adaptive Beamforming LMS, NLMS and RLS Algorithms For Smart Antenna System" IJRET: International Journal of Research in Engineering and Technology Volume: 04 Issue: 03 Mar-2015, page no. 199-202.
5. Prerna Saxena, A.G. Kothari: "Performance Analysis of Adaptive Beamforming Algorithms for Smart Antennas" 2014 International Conference on Future Information Engineering science direct, IERI Procedia 10 (2014) 131 – 137.
6. Minal. A. Nemade et.al : "Analysis of LMS and NLMS Adaptive Beamforming Algorithms" International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 7, July – 2014.
7. Balasem. S.S & S.K.Tiong, S. P. Koh : " Beamforming Algorithms Technique by Using MVDR and LCMV" World Applied Programming, Vol (2), Issue (5), May 2012. 315-324.
8. Arti M.K., Student Member, IEEE et.al: "Beamforming and Combining in Hybrid Satellite-Terrestrial Cooperative Systems" IEEE Communications Letters, VOL. 18, NO. 3, MARCH 2014 page no.483-486.
9. Thamer M. Jamel :" Performance Enhancement of Smart Antennas Algorithms for Mobile Communications System" International Journal of Circuits, Systems and Signal Processing Volume 8, 2014 page no. 313-320.

10. Ali Hakam et.all : "Robust Interference Suppression Using a New LMS Based Adaptive Beamforming Algorithm" 17th IEEE Mediterranean Electrotechnical Conference, Beirut, Lebanon, 13-16 April 2014.
11. Kapil Dungriyal et.al : " Performance of MIR-LMS algorithm for adaptive beam forming in Smart Antenna" IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 5, July 2014 .
12. Amara Prakasa Rao et.al: "Adaptive Beamforming Algorithms for Smart Antenna Systems" WSEAS Transactions on Communications Volume 13, 2014 page no. 44-50.
13. B. S. Reddy et.al: "Adaptive Digital Beam Forming using LMS Algorithm" IOSR Journal of Electronics and Communication Engineering, Volume 9, Issue 2, Vol. IV (Mar - Apr. 2014), PP 63-68.
14. Nu Nu Yi et.al : "Modeling and Simulation of Adaptive Beamforming for Mobile Communication" International Journal of Engineering Trends and Technology (IJETT) – Volume 9 Number 15 - Mar 2014 page no. 753-758.
15. Revati Joshi et.al: "Adaptive Beamforming Using LMS Algorithm" IJRET: International Journal of Research in Engineering and Technology Volume: 03 Issue: 05 May-2014 page no. 589-593.
16. SMITA BANERJEE et.al: "An LMS Adaptive Antenna Array" International Journal of Advanced Research in Engineering And Technology (IJARET) Volume 4, Issue 6, September – October 2013, pp. 166-174.
17. D. M. Motiur Rahaman : "Least Mean Square (LMS) for Smart Antenna" Universal Journal of Communications and Network 1(1): page no. 16-21, 2013.
18. Omar Mehanna, Student Member, IEEE et.al: "Joint Multicast Beamforming and Antenna Selection" IEEE Transactions on Signal Processing, VOL. 61, NO. 10, MAY 15, 2013.
19. D. B. Salunke et.al : " Analysis of LMS, NLMS and MUSIC Algorithms for Adaptive Array Antenna System" International Journal of Engineering and Advanced Technology (IJEAT), Volume-2, Issue-3 February 2013 page no.130-133.
20. L. Surendra et.al: "Performance Comparison of LMS, SMI and RLS Adaptive Beamforming Algorithms for Smart Antennas" IJCST Vol. 3, Issue 2, April - June 2012 page no.973-977.
21. Koteswara rao.Thokala et.al : "Steering An Adaptive Antenna Array by LMS NLMS and BBNLMS Algorithms" Global Journal of Advanced Engineering Technologies, Vol1-Issue3-2012page no.143-146.
22. Usha Mallaparapu et.al:"Non-Blind Adaptive Beam Forming Algorithms for Smart Antennas" IJRRAS 6 (4), March 2011 page no.491-495.
23. Jalal Abdulsayed Srar et.al: "Adaptive Array Beamforming Using a Combined LMS-LMS Algorithm" IEEE Transactions on Antennas and Propagation, VOL. 58, NO. 11, NOVEMBER 2010, page no. 3545-3557.
24. Raed M. Shubair et.al: "A Setup for the Evaluation of MUSIC and LMS Algorithms for a Smart Antenna System" JOURNAL OF COMMUNICATIONS, VOL. 2, NO. 4, JUNE 2007 page no. 71-77.
25. MOHAMMAD Tariqul Islam et.al : "MI-NLMS adaptive beamforming algorithm for smart antenna system applications" Journal of Zhejiang University SCIENCE A, 2006 7(10) page no.1709-1716.