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Adaptive Beamforming Algorithm for Smart Antenna: An Literature Survey

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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 and low complexity DOA estimation algorithms can be applied to decrease the required computational complexity. A Smart antenna system is used to maximize the output power of signal in desired direction and minimize the power in unwanted direction. Beamforming is a technique which is used in smart antennas for enhanced signal transmission and reception. In this paper we studied and analyzed different beamforming 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 beamforming algorithm for smart antenna to solve the purpose using MATLAB.

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

I.INTRODUCTION

As the growing calls for mobile communications is constantly increasing, the need for better coverage, advanced capability, and better transmission best rises. For this reason, a extra green use of the radio spectrum is required. Beam forming systems are able to successfully utilizing the radio spectrum and are a promise for a powerful approach to the existing wi-fi systems issues at the same time as reaching reliable and strong high-speed, excessive-information-fee transmission. The algorithm then makes use of this information from a user by comparing each received signal to the original sequence to find out the correct radiation pattern for that user. With this method, all received signals from each antenna element are used and are optimally combined to enhance the desired signal and to cancel unwanted interference [1].

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].

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].

The main function of antennas is to effectively transmit and receive the radio signals, there are some additional functions that smart antennas are required to accomplish which are:

A. **Direction of arrival [DOA]** estimation: In order to provide optimized transmission and reception, antennas are required to detect the direction of arrival of the required incoming signal. This information is then transferred to signal processor present within the antenna and required analysis is provided by the processor.

B. **Beam forming**: After the analysis from DOA estimation, the circuitry inside the antenna is able to optimize the beam pattern in certain required direction to provide the required performance. Beam forming is a technique which involves utilization of array of antennas to attain a wireless signal towards a specific direction, rather than having the signal spread in all directions as it normally would and the signals which have same frequency from different directions are abandoned [2].

II. LITERATURE REVIEW

Kun Zhang et.al: propose an unfolded augmented coprime array (UACA). Specifically, UACA can significantly reduce the number of sensor pairs with small spacing and hence inherently weaken the mutual coupling effect. Meanwhile, an increase of the DOFs and improved direction of arrival (DOA) estimation accuracy can be achieved in the presence of mutual coupling. As an application of UACA, we propose a decoupled interference-plus-noise covariance matrix (INCM) reconstruction method for robust adaptive beamforming (RAB) with UACA [1].

Prathviraj khande et.al: propose Smart antennas as an effective counter measure to achieve these necessities because they provide extensive bandwidth, less electromagnetic interference, flexibility, less weight, excessive velocity, phase control unbiased of frequency and coffee propagation loss. Smart antennas integrate the antenna array with sign processing to optimize mechanically the beam pattern in reaction to the acquired signal. Beam forming may be used for both radio and sound waves; it has determined numerous programs in radar, sonar, seismology, wireless communications, radio astronomy, speech and bio-medicine. This paper discusses the algorithm for blind and non blind adaptive beam forming technique for reliable wireless communication [2].

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 [3].

Ashraf et.al: Proposes a hybrid non-blind beamforming algorithm that combines the Normalized Least Mean Square (NLMS) algorithm and the Recursive Least Square (RLS) algorithm to exploit the advantages of both algorithms and avoid their drawbacks. The hybrid NLMS/RLS algorithm solves many problems of the other non-blind algorithms. A comparative study between the proposed algorithm and other non-blind beamforming algorithms is introduced to illustrate the points of strength of the proposed algorithm. The hybrid NLMS/RLS algorithm is applied to different types of patch array antenna with resonance frequency 10GHz to demonstrate the performance of the proposed algorithm to each array antenna type.[4]

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 [5].

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 [6].

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 [7].

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 [8].

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 [9].

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 [10].

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 [11].

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 Direction of arrival with 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 combine 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.

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