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Performance of Music LMS Algorithm for Smart Antenna

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Abstract- ***This paper presents of Smart antenna system based on the direction of arrival (DOA) estimation and adaptive beamforming. Direction of arrival (DOA) estimation is based on the MUSIC for identify the direction of signal and adaptive beamforming is achieved by LMS algorithm.***

The smart antenna system designed involves a hardware part which provides real data measurement of the incident signal received by sensor array. Results obtained verify the improved performance of the smart antenna system .This take the form of sharper peaks in the MUSIC angular spectrum and deep nulls in the LMS array beam pattern.

Keywords—**Smart antenna, Adaptive Beamforming, LMS, MUSIC, DOA**

I. INTRODUCTION

The demand for mobile communication resources has increased phenomenally over the past few years. Adaptive or smart antenna techniques have emerged as a key way to achieve the ambitious requirements introduced for current and various types of beamforming schemes.

A smart antenna is commonly defined as a multi-element antenna where the signals received at each element are intelligently and adaptively combined to improve the overall performance of the wireless system, with the reverse performance on transmit. Smart antennas have the property of spatial filtering, which make it possible to receive energy from a particular direction while simultaneously blocking it from another direction. The benefit of smart antenna is that they can increase range and capacity of system while helping to eliminate both interference and fading. For optimal processing, the typical objective is minimizing the output signal to noise ratio (SNR).For an array with a specified response in the direction of the desired signal, this is achieved by minimizing the mean output power of the processor subject to specified constraints. In the absence of the errors, the beam pattern of the optimized array has the desired response in the signal direction and reduced response in the direction of unwanted interference.

II.SMART ANTENNA

The concept of using multiple antenna and innovative signal to serve cell more intelligently has existed for many years. In fact, varying degree of relatively costly smart antenna system has already been applied in defense system. Until recent years, cost barriers have prevented their use in commercial system. The advent of powerful low cost digital signal processor (DSPs), general purpose processors as well as innovative software-based signal processing techniques (algorithm) have made intelligent antenna practical for cellular communication system.

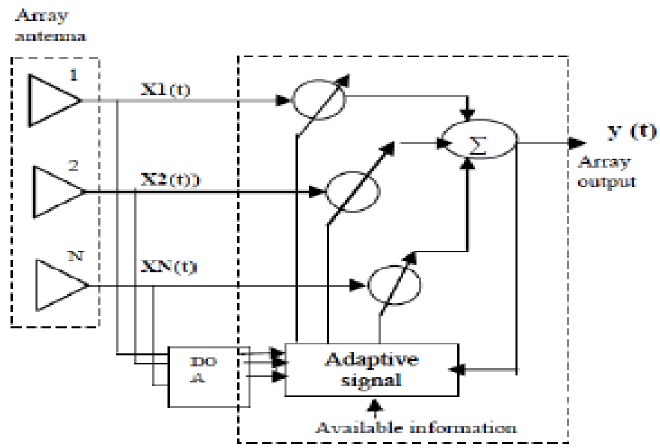

Fig. 1. Functional block diagram of smart antenna

The smart antenna system can be divided mainly into three parts.

- The first one performs the direction of arrival (DOA) estimation and determines the number of incoming signals.
- The second part performs the DOA classification. It finds out which signals originate from the user and which ones from the interferers.
- The third part consists in the beamforming algorithm It forms an antenna pattern with a main beam steered in the direction of the user, while minimizing the influence of the interfering signals and the noise.

In this paper we make the following assumption about antenna array.

1) There is no mutual coupling element.
2) All incident fields can be decomposed into discrete number of plane wave. That is there is finite number of signal.
3) The bandwidth of the signal incident on the array is small copared with the carrier frequency.

III. ADAPTIVE BEAMFORMING

The adaptive algorithm used in the signal processing has a profound effect on the performance of a Smart Antenna system. Although the smart antenna system is sometimes called the ―Space Division Multiple Access, it is not the antenna that is smart. The function of an antenna is to convert electrical signals into electromagnetic waves or vice versa but nothing else. The adaptive algorithm is the one that gives a smart antenna system its intelligence. Without an adaptive algorithm, the original signals can no longer be extracted. In the fixed weight beamforming approach the arrival angles does not change with time, so the optimum weight would not need to be adjusted. However, if desired arrival angles change with time, it is

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necessary to devise an optimization scheme that operates on-the-fly so as to keep recalculating the optimum array weight that's done by using adaptive beamforming algorithm.
The task of the algorithm in a Smart antenna system is to adjust the received signals so that the desired signals are extracted once the signals are combined. Various methods can be used in the implementation of an adaptive algorithm.

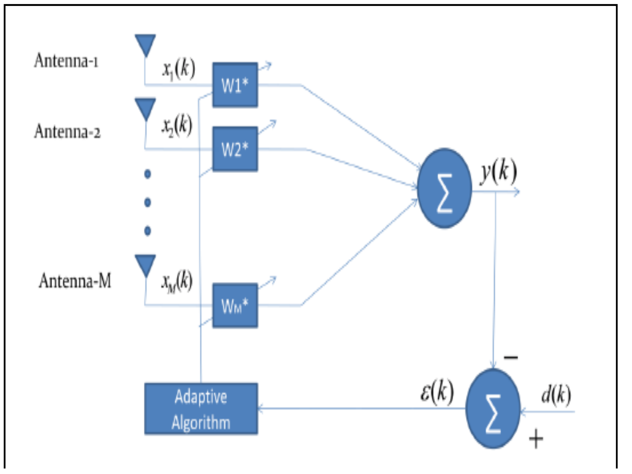

Fig.2 Block diagram of adaptive beamforming algorithm

In comparison, an human can even listen to sound which is weaker than the interference. The adaptive algorithm in a smart antenna system serves a similar purpose as the brain in this analogy, however it is less sophisticated. Our brain can perform the above signal selection and suppression with only two ears, but multiple antennas are required for the adaptive algorithm so that enough information on the user signals can be acquired to perform the task. In human beings, some people are more intelligent than others. In order for them to be more intelligent, they have to have a more developed brain. Similarly, some algorithms are smarter than other algorithms. A smart algorithm usually requires more resources than algorithms that are less intelligent. Unlike our brain which is a free resource, more resources in the world of technology always mean more expensive components and more complicated system.

IV.LEAST MEAN SQUARE (LMS)

A Uniform Linear Array (ULA) with N isotropic elements, which forms the integral part of the adaptive beamforming

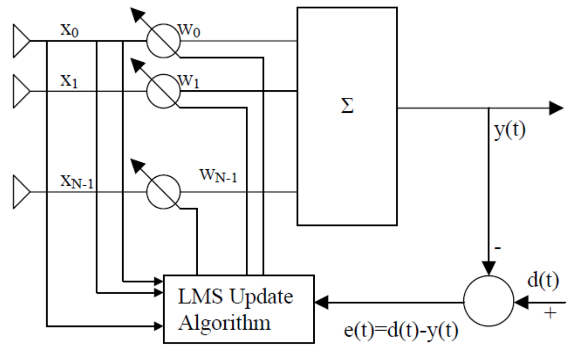

Fig.3- LMS adaptive beamforming network

system, is shown [Fig-3].The output of the antenna array is given by,

$$x(t)= s(t)a(\theta_o) + \sum_{i=1}^{N_u} u_i(t)a(\theta_i) \quad (t)$$

III.

s(t) denotes the desired signal arriving at angle θ_o and *u(t)* denotes interfering signals arriving at angle of incidences θi respectively. $a(\theta_o)$ and $a(\theta i)$ represents the steering vectors for the desired signal and interfering signals respectively. Therefore it is required to construct the desired signal from the received signal amid the interfering signal and additional noise *n(t)*. The outputs of the individual sensors are linearly combined after being scaled using corresponding weights such that the antenna array pattern is optimized to have maximum possible gain in the direction of the desired signal and nulls in the direction of the interferers. The weights here will be computed using LMS algorithm based on Minimum Squared Error (MSE) criterion. Therefore the spatial filtering problem involves estimation of signal *s(t)* from the received signal *x(t)*(i.e. the array output) by minimizing the error between the reference signal *d(t)*, which closely matches or has some extent of correlation with the desired signal estimate and the beamformer output *y(t)* (equal to *wx(t)*). This is a classical Weiner filtering problem for which the solution can be iteratively found using the LMS algorithm.The Least Mean Square (LMS) algorithm, introduced by Widrow and Hoff in 1959 [3] [9] [10] is an adaptive algorithm, which uses a gradient-based method of steepest decent [8]. LMS algorithm uses the estimates of the gradient vector from the available data. LMS incorporates an iterative procedure that makes successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error.

V.MULTIPLE SIGNAL CLASSIFICATION (MUSIC)

The MUSIC algorithm. MUSIC algorithm is a high resolution Multiples **Si**gnal **C**lassification technique based on exploiting the Eigen structure of the input covariance matrix. It provides information about the number of signals, DOA of each signal, strengths and cross correlations between incident signals, noise power etc. Consider a N-element linear array that detects M signals impinging on it whose directions of arrival need to be known. From the previous discussion we know that the received signals at the output of the array have the following form:

$$x(t)=A(\theta)s(t)+n(t)$$

Or in matrix notation it can be represented as

$$x=As+n$$

Where S is the signal vector, A is the array propagation vector and n is the noise vector with zero mean and variance σ^{2}.

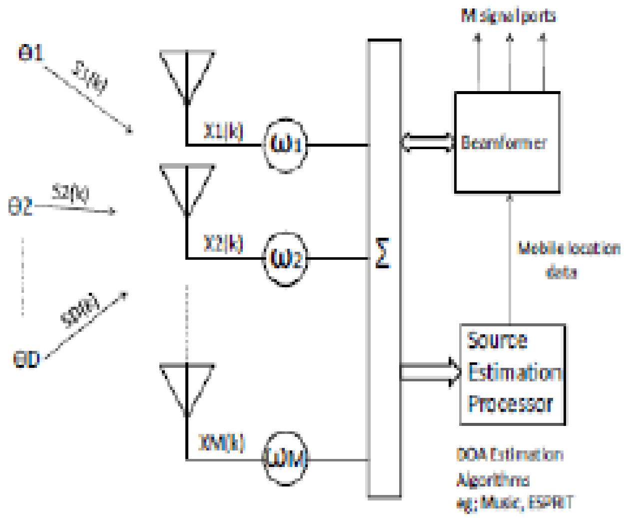

Fig.4 M-element antenna array with D arriving signal

If the number of signal impinging on M element array is D, the number of signal Eigen value and Eigen vector is D and number of noise eigenvalue and eigenvector is M-D. The array correlation matrix with un-correlation noise and equal variance is then given by

$$R_{XX} = A^{*}R_{SS}{}^{*}A^{H}+{*}\,\sigma_n^{2}{*}i$$

Where $A=[a(\Theta_1)\ a(\Theta_2)\ a(\Theta_3)\ ---\ a(\Theta_D)]$ is M x D array steering matrix and $R_{ss}=[s_1(k)\ s_2(k)\ s_3(k)\ ---\ s_D(k)]^T$ is D x D source correlation matrix.

R_{ss} has D eigenvectors associated with signals and M – D eigenvectors associated with the noise. We can construct the M x (MD) subspace spanned by the noise eigenvectors such that

$$V_N=[v_1\ v_2\ v_3 \text{ --------- } v_{M-D}] \quad ---$$

The noise subspace eigenvectors are orthogonal to array steering vectors at the angles of arrivals Θ_1, Θ_2, Θ_3, Θ_D and the MUSIC Pseudospectrum is given as

$$P_{MUSIC}(\Theta) = 1/abs\left((a(\Theta)^{H} {*} V_N {*} V_N{}^{H} {*} a(\Theta)\right)$$

However when signal sources are coherent or noise variance vary the resolution of MUSIC diminishes. To overcome this we must collect several time samples of received signal plus noise, assume ergodicity and estimate the correlation matrices via time averaging

$$R_{xx} = A{*}R_{ss}{*}A^{B}+A{*}R_{sn}+R_{sn}{*}A^{H}+R^{nn}$$

VI. CONCLUSIONS

This paper presents the result of direction of arrival estimation using LMS MUSIC these two methods have greater resolution and accuracy and hence these are investigated much in detail. By algorithm improved of the sharper peaks graph and smaller error. The LMS algorithm is most commonly used adaptive algorithm because of its simplicity and a reasonable performance. Since it is an iterative algorithm it can be used in a highly time-varying signal environment. It has a stable and robust performance against different signal conditions. However it may not have a really fast convergence speed compared other complicated algorithms. The Smart Antenna systems are the antennas with intelligence and the radiation pattern can be varied without being mechanically changed .With appropriate adaptive algorithms such as LMS MUSIC algorithm.

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