COMPARITIVE ANALYSIS OF BEAM FORMING

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Abstract **— To provide effective communication among the mobile users, interference has to be reduced to maximum extent. Reducing the interference plays a major role in providing effective communication among mobile users. By using smart antennas we can increase the capacity and coverage area of wireless sensor networks. By increasing the capacity and coverage area it is possible to provide line of sight communication and continuous coverage of network for remote users .By using Adaptive Beam forming (ABF) algorithm we can direct the arrays beam in the desired direction at the same time nullifying the interference signal. This paper depicts the methods for formation of beam which decreases the computational complexity of conventional LMS algorithm, and for the first time applied to smart antenna system by newly proposed signum algorithm.**

Index Terms—*Least Mean Square, Beamforming.*

I. INTRODUCTION

In the present generation it is observed that there is a enormous increase in the development of wireless access technologies which leads to newly upcoming wireless internet services and advanced cellular systems. A large amount of traffic is experienced due to large number of mobile users and high bit rate data services. This trend is continued for both second and third generation. This high amount of traffic forces the operator and manufacturer to provide large amount of capacity in the network. providing this capacity is a major problem in the network. The co-channel interference and fading are the two major problems in providing the increase in capacity of the network.

Smart antenna systems have many antennas which provide good quality of service (QOS), extended radio coverage and increased system capacity. QOS is achieved by steering the antenna pattern in the desired direction. High angle resolution is achieved by adding more number of antennas. But this leads to rise in the computational complexity and provides latency in computing the weight vectors. The processing of received signal is done by weight vectors. in switched beam algorithm there is less computational complexity as the weight vectors are precalculated and are kept at different angles. In fully adaptive algorithms the weight vectors are newly calculated according to change in the direction of user. This provides accurate tracing but in turn increases the computational complexity. Various adaptive filters are used for beam steering. Among these LMS algorithm is most frequently used. Although we know that computational complexity for LMS algorithm's high, so in order to reduce the computational complexity and provide good performance we modify the LMS algorithm in to SE-LMS algorithm.

II.BEAM-FORMATION

Direction of arrival and antenna array beam patterns are generated by adaptive beam forming algorithms and the required computations for beam pattern generation are done by digital signal processor (DSP), DSP, analog to digital (A/D) converter are present in smart antennas. Using adaptive beam forming algorithm the amplitudes of uniform linear array are adjusted with a set of complex weights. The array output is optimized by ABF such that maximum radiated power is in the direction of desired user and nulls in the other direction. These nulls in turn cause interference in the adjacent cells.To provide reliable link smart antenna performs two operations.

(i) Estimation of DOA(Direction of arrival)
(ii) ABF (Adaptive Beam Forming).

DOA operates on the received signal and calculates the direction of incoming signal. A beam former is a linear array of antennas with electronically steered outputs. The received signal's weights are then computed using ABF. In spatial temporal filtering signal's are distinguished according to the direction of arrival of signal ,frequency.ABF steers the pattern along with direction of required signal , and a minimum amplitude side lobe is produced at the positions of interfering signals. The dynamic updating of complex weights is done by ABF. The linear array of antennas consists of isotropic antenna elements which absorbs only the spatial information from the electromagnetic signals and the received signals weights are computed. Beam forming can also be defined as tuning the sharpness of the antenna in a particular direction for a particular frequency.

III.ADAPTIVE BEAMFORMING

Adaptive beam forming is a technique where antenna elements are exploited to gain maximum number signals in particular direction and the signals in the other direction with same frequency are rejected. The weights are calculated and are updated adaptively according to the real time based on the signal samples. The narrow beams are sent in the desired direction and minimum output power in the interferer's direction, which leads to rapid growth or improvement in signal to interference noise ratio. Many antenna elements are combined by the smart antenna which is capable of signal processing and optimizing the received signal. To produce the desired output in the mobile user direction. Smart antennas are broadly classified into switched beam forming and adaptive beam forming systems. Adaptive antennas are called as the smartest antennas as they are persistent to the changes in their surroundings. The weight of the antenna is updated adaptively such that the gain is maximized in the desired direction and the gain in the other directions are minimized (i.e in the jammer directions the gain is minimized).hence adaptive beam forming is also called as digital beam forming.

IV.SIMULATION METHODOLOGY OF ADAPTIVE BEAMFORMING

1. Calculate Lx1 steering vector in user wished direction θ_0 .

$$a(\theta) = \begin{bmatrix} 1 \\ e^{i2\pi d\sin\theta} \\ \vdots \\ \vdots \\ e^{i2\pi d(L-1)\sin\theta} \end{bmatrix}$$

2. LxM array manifold vector must be computed or with respect to 'm' jammer angles $\theta_1, \theta_2, ..., \theta_M$.

3. Continuous time signal from base-band frequency must be subjected to sampling to extract the signal samples 's'.

4. Calculate the step size

$$\mu = \frac{2}{\lambda_{\max} + \gamma}$$

5. Calculate induced signal and error signal for all signal samples

6. Compute array factor

7. Array factor versus angles are plotted.

V. LEAST MEAN SQUARE ALGORITHM

LMS algorithm is most frequently used adaptive beam forming algorithm, being employed in several communication applications, but the computational complexity with respect to complex weights. So we made an attempt to reduce the complexity in the complex weights, without any degradation in the performance by applying signum function as a result time and power can be saved, which is discussed and shown in the result section

While using LMS algorithm, complete information about reference signal must be known. LMS is a well known algorithm in adaptive signal processing. Various kinds of modifications were introduced to increase its performance.

The weight vector of LMS is :

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

V1.SIGNUM ERROR LEAST MEAN SQUARE

The above referred algorithm was first time applied to the smart antenna with respect to beam formation; in SELMS a lot of simplification is necessary in few of the applications. We can consider high speed digital communication is also one such application. In SELMS the weight co-efficient's of LMS are altered by preceding the error signal with sign operator.

The weight vector for Signum Error Least Mean Square (SE-LMS)

$$w(n+1) = w(n) + \mu x(n) \operatorname{sgn}(e(n))$$

Where,
x(n) = induced signal and μ = step size,

sgn(e(n)) = is defined as

$$\operatorname{sgn}(e(n)) = \begin{cases} 1 & e(n) > 0 \\ 0 & e(n) = 0 \\ -1 & e(n) < 0 \end{cases}$$

In SELMS algorithm sign of error changes only magnitude of correction that is used to compute weight and does not alter the direction. The signum error value ranges from +1 to -1. It is equal to +1 when error signal is larger than zero and it is equal to -1 when error signal is smaller than zero and it is equal to zero when error signal is zero and it is a ideal case.

V11. SIMULATION RESULTS

Table 1: Input for the algorithms

Algorithms	Antenna elements	Look direction	Jammer direction
LMS	100	45	[10,60,70]
SELMS	100	45	[10,60,70]

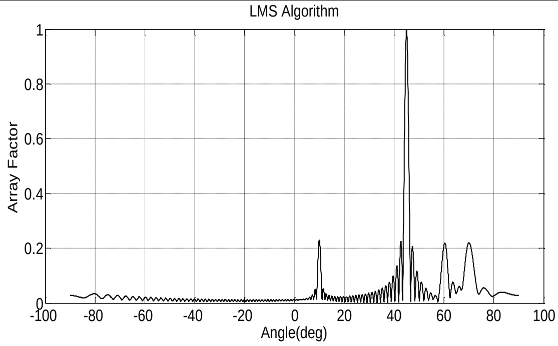

Fig 1: Beam plot of LMS algorithm

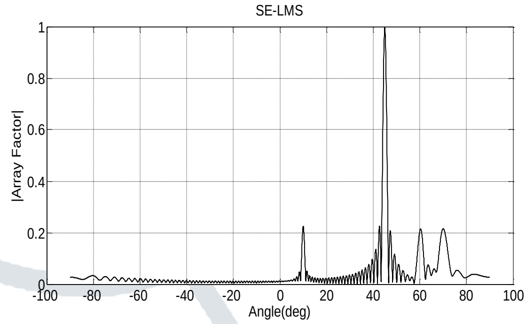

Fig 2: Beam plot of SELMS

Table 2: Comparison of algorithms with respect to main beam formation (performance)

Algorithms	Antenna elements	Look direction	Jammer direction
LMS	100	40	[10,5]
SELMS	100	45	[10,5]

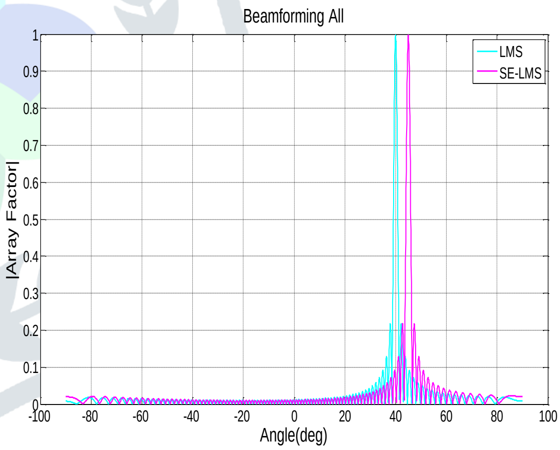

Fig 3: comparison of SELMS with LMS

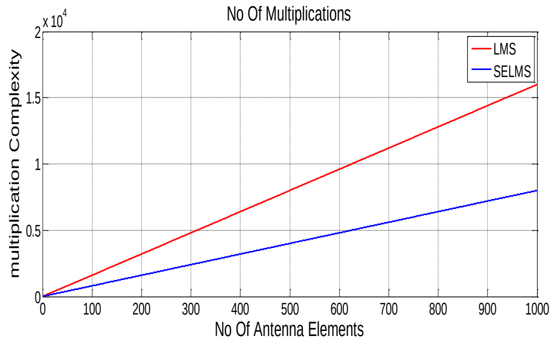

Fig 4: complexity graph with respect number of multiplications

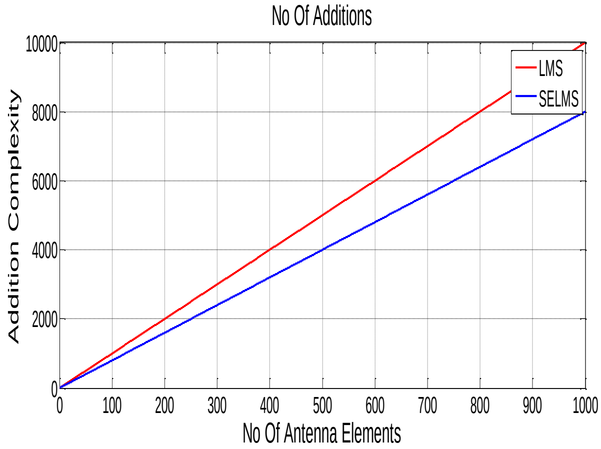

Fig 5: complexity graph with respect number of addition

Conclusion

A newly proposed adaptive algorithm for beam formation namely SELMS is explained along with LMS algorithm. The depicted algorithm performs well in formation of main lobe along the look direction and reduces interference at a direction of not interest. The proposed method reduces the complexity without any degradation in the performance which is shown in result section.

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