A New High Convergence Beam Forming Algorithms for Mobile Communication

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Abstract - *In order to reduce the traffic problems in mobile communication network, the mobile communication system at base stations should use spatial filtering techniques this can be achieved by using Adaptive antenna system at base station. Adaptive antenna system works on two algorithms DOA and ABF, these algorithms have to be optimized in order to achieve better performance. This paper suggests a new Novel Error Data Normalized Step Size (EDNSS) beam forming algorithm which has better convergence and lesser Mean Square Error as compared to existing beam forming algorithms. This paper compares Error Data Normalized Step Size (EDNSS) with ENSS with respect to Mean Square Error and Beam forming.*

Keywords: Beam forming Algorithms, EDNSS, ENSS MATLAB, Smart Antenna.

1. INTRODUCTION

Beam forming is a signal processing technique used in sensor arrays for directional signal transmission or reception. The spatial selectivity is achieved by using adaptive or fixed receive/transmit beam former units. Beam forming can be used for both radio and sound waves. It has found numerous applications in Radar, Sonar, Seismology, Wireless Communication, Radio Astronomy, Speech, Acoustics and Biomedicine. Adaptive Beam forming is used to detect and estimate the signal of interest at the output of a sensor array by means of data adaptive spatial filtering and interference rejection.
The main objective of this spatial signal pattern shaping is to simultaneously place a main beam toward the Signal-of-Interest (SOI) and ideally nulls toward directions of interfering signals or Signals Not of Interest (SNOIs).

2. LITERTURE SURVEY

The latest advancements in the field of smart antenna, understanding of Direction of Arrival and Beam forming algorithms are explicitly described in the following papers. George V Tsoulos [2] presents a general overview of smart antenna along with their application and potential benefits for mobile communication systems. It begins with the description of various types of smart antenna and then provides information about multiple benefits involved such as increased transmit power and capacity. It reaffirms the fact that exploiting different characteristics of smart antennas can lead to several operational benefits for a communication system. Jack H. Winters [5] in his paper gives an overview about the need for Smart Antennas (SA) in mobile systems. The paper briefs about the various Beam forming and DOA algorithms along with their hardware implementation. Finally the author has concluded the fact that, the implementation of SA has little impact on the physical layer thereby improving the Quality of Service (QoS) and reducing interference at the same time.

3. ADAPTIVE BEAM FORMING

Adaptive Beam forming is a technique in which an array of antennas is exploited to achieve maximum reception in a specified direction while rejecting signals of the same/different frequency from other directions. The weights are computed and adaptively updated in real time based on signal samples. The adaptive process permits narrower beams in look direction and reduced output in other directions, which results in significant improvement in Signal to Interference Noise Ratio (SINR).

3.1. Adaptive Beam Forming Problem Formulation

Considering a problem of wiener filtering [1], with reference to a non stationary process.
Let w(n) denote unit sample response of the FIR wiener filter that produces minimum mean square estimate of desired signal s(n).The output of the filter is given by

$$y(n)=\sum_{k=0}^{L} w(k)x(n-k) \quad (1)$$

Where L is the order of filter. If x(n) and s(n) are wide sense stationary processes then error signal is given by.

$$e(n) = s(n) - y(n) \quad (2)$$

The filter coefficients or beam forming array weights w(n) that minimizes the Mean Square Error $|e(n)|^2$ is found by solving the Weiner-Hopf equation given by

$$w(n) = R_{xx}^{-1} r_{sx} \quad (3)$$

Where, Rxx is the autocorrelation of induced signal x(n) and Rxx is the cross correlation between reference signal s(n) and induced signal x(n) . In many aspects, the Design of adaptive Beam former is much more difficult than design of beam former based on Weiner Hopf equation. This problem can be simplified by considering the weight update equation to be

$$w(n+1) = w(n) + \Delta w(n) \quad (4)$$

Where, is the correction applied to calculate new weights. This type of weight updating for w(n) forms the heart of every beam forming algorithm and each of the beam forming algorithms varies in terms of computation of weights. In a practical case, if s(n) the signal samples corresponding to look direction , i(n) is interfering signal samples corresponding to jamming directions and $n_0(n)$ is noisy signal samples due to receiver components. The induced signal is given by

$$x(n) = s(n) \propto (\theta_0) + \sum_{i=1}^{M} i_i(n)\, \alpha(\theta i) + n_o(n) \quad (5)$$

Where, M is number of jamming sources, A(ɵ) is desired steering vector and A(ɵ) is the steering vector corresponding to ith interference signal. Since jamming signals (or interfering signals) are of no interest, it is assumed I(n1) = I(n2)=.......I(nj) with this modification equation (6) can be written as

$$x(n) = \propto (\theta_0)\, s(n) + i(n) \sum_{i=1}^{M} \alpha(\theta i) + n_o(n) \quad (6)$$

In matrix notation, induced signal can be written as

$$X = A_\theta S + A_{in} I_i + N \quad (7)$$

Where ,X represents L x Ns induced signal matrix, Ns is total number of samples, 'L' represents number of array elements,' S' represents reference signal samples. A(ɵ) is desired steering vector of order Lx1, I represents interference signal samples matrix of order 1xNs , N represents Gaussian noise matrix of order LxNs and A is Lx1 column vector that is obtained by adding all columns of array manifold vector as shown (7)

$$A_{in} = \begin{bmatrix} 1 \\ eix1 \\ . \\ . \\ . \\ eiy1 \end{bmatrix} + \begin{bmatrix} 1 \\ eix2 \\ . \\ . \\ . \\ eiy2 \end{bmatrix} + \ldots\ldots\ldots + \begin{bmatrix} 1 \\ eixm \\ . \\ . \\ . \\ eiym \end{bmatrix} \quad (8)$$

X1=2пdsin ɵ1 , X2=2пdsin ɵ2, Xm=2пdsin ɵj
Y1=2пd(L-1)sinɵ,Y2=2пd(L-1)sin ɵ
Ym= Ym=2пdsinɵ

Where, 'd' is the distance between antenna elements, ɵ1, ɵ 2,ɵ 3……… ɵ jare directions of jamming signals and M is number of jamming signals

4. VARIABLE ERROR DATA NORMALIZED STEP SIZE (VED-NSS)

VED-NSS algorithm [4] has greater noise reduction performance and performs convergence analysis of Error Data Normalized Step-Size (EDNSS) algorithm. Adopting VED-NSS provides fast convergence at early stages of adaptation, while ensuring small final misadjustment. In VED-NSS algorithm step size is varied between two bounds viz μ_{upper} and μ_{lower}, which will provide fast convergence. The upper and lower bound are given by (9)

$$\mu_{upper} = \frac{2}{3\, tr(cov(x))}$$

$$\mu_{lower} = \frac{2}{tr(Rx)} \quad (9)$$

Where tr(cov(x)) is the trace of covariance tr(Rx)is trace of auto correlation matrix.
The weight update equation in VED-NSS algorithm is given by

$$w(n+1) = w(n) + \frac{\mu(n+1) e(n) x(n)}{(\alpha 1 e s + (1-\alpha_1)} \quad (10)$$

Where, α1 a constant chosen for fast convergence, μ(n+1)is defined as i equation and e_s is the normalized error given by

$$e_s = e^*(n)\, e(n) \quad (11)$$

The step size is varied between two bounds during each iteration by using

$$\mu(n+1) = \mu upper \text{ if } \mu(n+1) > \mu upper$$
$$= \mu lower \text{ if } \mu(n+1) < \mu\, lower$$

=μ(n+1) otherwise (12)

5. ERROR NORMALIZED STEP SIZE (ENSS)

ENSS algorithm is same as VED-NSS [6] except that the weight update consists of normalization of error vector. The weight updation in ENSS algorithm is given by

$$w(n+1) = w(n) + \left[\frac{\mu(n+1)}{\left(1+\mu(n+1)e_S(n)\right)} \right] e(n)x(n) \tag{13}$$

6. RESULTS

Table1: Less Antenna Elements and Single Jammer

Algorithm	Desired Angle	Jammer Angle	No Of Antenna Elements
VED-NSS	70	5	8
ENSS	60	10	8

VED-NSS:

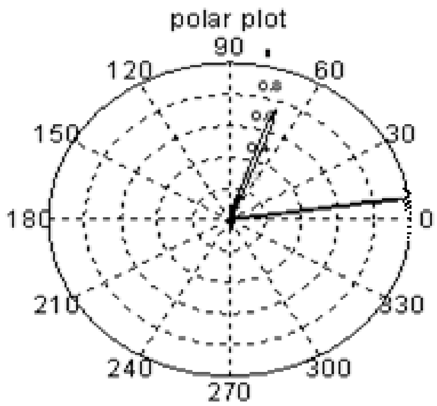

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Fig1: Polar Plot for VED-NSS Algorithm.

Fig1 shows that the VED-NSS algorithm is capable of forming main beam at desired direction of 70 degree with less antenna elements.

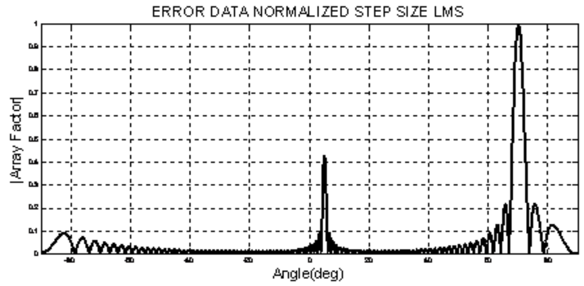

Fig2: Beam Plot for VED-NSS Algorithm1

Fig2 shows that the VED-NSS algorithm is capable of forming main beam at desired direction of 70 degree with less antenna elements

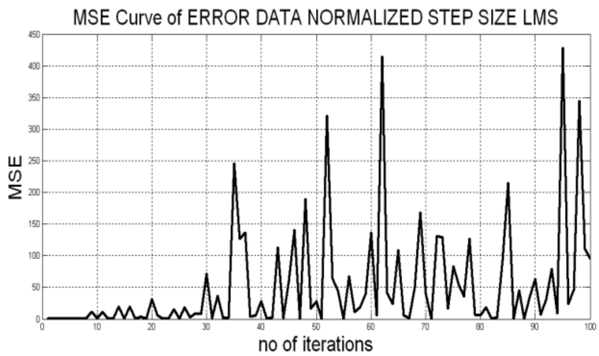

Fig3: MSE Plot for VED-NSS Algorithm.

Fig3 shows the mean square error variation for VED-NSS algorithm for 100 iterations

ENSS:

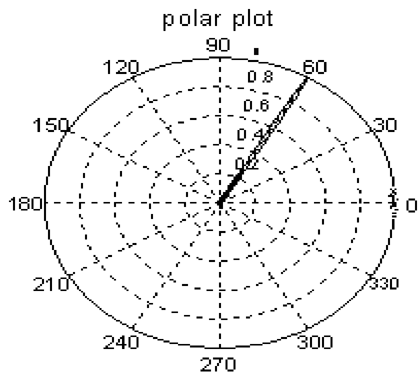

Fig4: Polar Plot for ENSS Algorithm.

Fig4 shows that the ENSS algorithm is capable of forming main beam at desired direction of 60 degree with less antenna elements

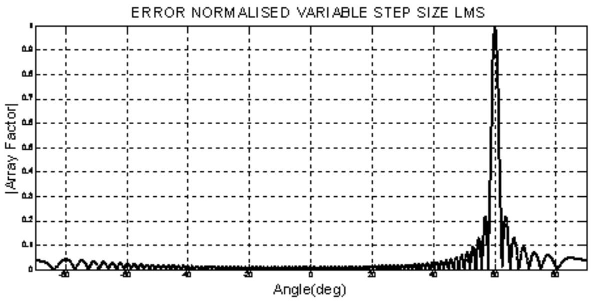

Fig5: Beam Plot for ENSS Algorithm1

Fig5 shows that the ENSS algorithm is capable of forming main beam at desired direction of 60 degree with less antenna elements.

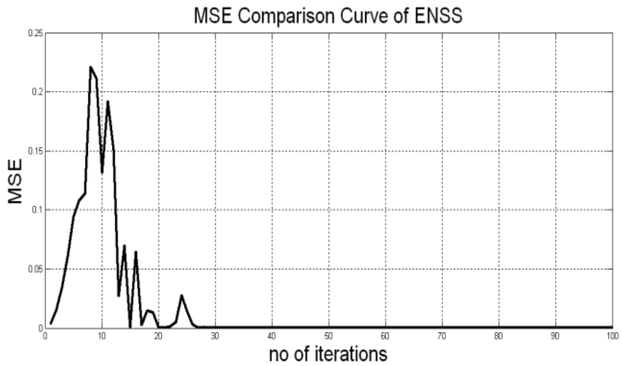

Fig6:MSE Plot for ENSS Algorithm.

Fig6 shows the mean square error variation for ENSS algorithm for 100 iterations

7. CONCLUSIONS

In this paper we have modified the adaptive filtering algorithms and applied for smart antenna beam forming. From the simulations results one can conclude that the ENSS is the best because it converges at a faster rate and MSE is also less as compared to EDNSS algorithm. Secondly ENSS produces a sharper beam towards the desired user and has very much less side lobe levels as compared to EDNSS.

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BIOGRAPHIES

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