Simulation of Beamforming Solution of Intereference Reduction for High Altitude Systems

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Abstract-
Interference reduction is vital for being able to effectively communicate with mobile users in rugged terrain and mountainous regions .It is proposed to outfit a high flying airborne node with a Code Division Multiple Access (CDMA) base station in order to provide line of sight communications and continual coverage to the remote users in a highly congested environment. The results will One approach to increasing capacity and coverage zones for the servicing wireless station is to use smart antennas.

This paper simulates many Beamforming algorithms namely SMI, LMS, VSSLMS, Griffiths, VSSG, EDNSS and ENSS. The algorithms provides different ways by which we can calculate the phase shifts and apply to individual antenna elements so that main beam is formed in the look direction and nulls or reduced radiation is formed in the jammer directions.

The two algoithms namely EDNSS & ENSS from adaptive filtering and applied to smart antenna concepts of beamforming. The ENSS algorithms achieves less error and high convergencence as compared to existing beamforming other algorithms.

Keywords—Smart Antenna, Beam forming Algorithms, least mean square (LMS),variable step size LMS, Griffth's variable step size Griffth's, variable error data normalized step size(EDNSS) error normalized step size(ENSS).

I. Introduction

In recent years a substantial increase in the development of broadband wireless access tech nologies for evolving wireless internet services and improved cellular systems has been observed. It is widely foreseen that in the future an enormous rise in traffic mobile and personal communication systems. This is due to an increase in number of users and introduction of new high bit rate data services. This trend is observed for second-generation systems as well and it will most certainly continue for third-generation systems.

The rise in traffic put a demand on both manufacturers and operators to provide sufficient Capacity in the network, this becomes a major challenging problem for the service providers to solve.

There are certain negative factors like co-channel interference and fading in the radiation environment contributing to the limit in the capacity. Smart antenna is one such development in this direction to full fill the feature requirements of mobile networks.

Snart Antenna with signal processing algorithm used to identify spatial signature such as DOA of signal and to locate desired beam .

SMART ANTENNA

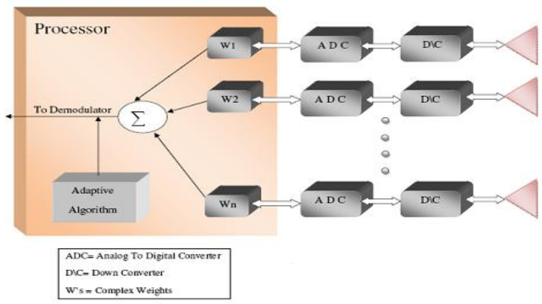

Fig-1: Block diagram of smart antenna system

It locates signal of interest (SOI) using Direction of Arrival (DOA) algorithm. The two basic functions of any smart antenna are (DOA) Estimation and Adaptive antnnas) arranged in linear fashion (uniform linear array) to extract the spatial information from the waves.The signal received at sensor is sent for computation of weights.

II. Implementation

Let w(n) denote unit sample response of the FIR wiener filter that produces minimum mean square.A beamforming is a set of sensors arranged in a linear fashion (uniform linear array).It is a signal processing technique used in sensor array for directional signal transmission or reception.
The signal received at sensor is sent for computation of weights.
$W(n+1)=w(n)+\Delta w(n)$
Where W(n) is beamforming array weights, $\Delta w(n)$ is correction applied to new weights.

1. Least Mean Square (Lms)

The LMS algorithm is the most widely used adaptive beamforming algorithm, being employed in several communication applications. It has gained popularity due to its low computational complexity and proven robustness. The LMS algorithm changes the weight vector w(n) along the direction of the estimated gradient based on the steepest descent method. In employing the LMS algorithm, it is assumed that sufficient knowledge of the reference signal is present.

The weight vector update equation assumes a particular simple form as given by

$$w(n+1) = w(n) + \mu e(n) x^*(n) \quad (1.1)$$

Where, μ is the step size which can be in the range given by

$$0 \le \mu \le \frac{2}{3tr(R_{xx})} \quad (1.2)$$

2. Variable Step Size Lms (Vss-Lms)

Variable Step-Size LMS (VSS LMS) algorithms are used, with the intention of decreasing misadjustment and to maximize convergence rate. Step size is larger when the estimate is far from the optimum value and a smaller step-size as it approaches the optimum value. The performance of this method is promising especially in non stationary environment.

The step size is calculated, during each iteration by using equation

$$\mu(n+1) = \alpha \mu(n) + \gamma |e(n)|^2 \quad (2.1)$$

Where, 'α' indicates the correlation of the present step size to the previous step size, it is in the range $0 < \alpha < 1$ and γ is used to control convergence characteristics of VSS-LMS algorithm, $\gamma = 0.5$ and error signal e(n) is given by

e(n)=d(n)-y(n) (2.2)

During each iteration the step size is changed as

$$\mu(n+1) = \mu_{upper} \quad if \quad \mu(n+1) > \mu_{upper}$$
$$= 0 \quad if \quad \mu(n+1) < 0$$
$$= \mu(n+1) \quad otherwise$$

(2.4)

3. Griffiths' Algorithm

Griffiths' algorithm [16] utilizes certain a priori knowledge (when available) to create an effective real time adaptation process. The algorithm can be used for a number of applications including Noise Control, Adaptive Beamforming and Acoustic Signal Processing. The algorithm is ideal when the cross-correlation between the desired response and the input signal vector (i.e. the inputs to the weights) are known a priori. In this case, the algorithm can be executed without the need for a real time response input s(n).

The weight update equation for Griffith's algorithm can be derived by using LMS algorithm, which is given by

$$w(n+1) = w(n) + 2\mu\, e(n)\, x(n)$$
$$= w(n) + 2\mu\, (d(n) - y(n))\, x(n)$$
$$= w(n) + 2\mu\, r_{sx} - 2\mu\, y(n)\, x(n) \quad (3.2)$$

Where, μ is the step size, r_{sx} is the cross- correlation and $y(n)$ is the array output.

4. Variable Step Size Griffiths' (Vssg)

The Variable Step Size Griffiths' algorithm [17] is a combination of the Variable Step Size LMS algorithm and the Griffiths' algorithm. The algorithm is expected to combine the merits of the Variable Step Size LMS algorithm and Griffiths' algorithm.

The motivation behind this algorithm is, the use of an algorithm which would achieve faster convergence through the use of a variable step size LMS algorithm and a smoother gradient through the use of the Griffiths' algorithm..

The weight update equation in case of VSSG algorithm is given by

$$W(n+1) = w(n) + \frac{\mu l}{\|x\|} \quad (4.1)$$

The value of l is computed by taking the difference between cross correlation of reference signal with induced signal and cross correlation between array output and induced signal given by

$$l = r - y^* x(n) \quad (4.2)$$

The upper bound for step size in VSSG is given by

$$\mu_{upper} = 0.07 \quad (4.3)$$

5. Variable Error Data Normalized Step Size Algorithm (Ved-Nss)

VED-NSS algorithm [8] 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 [22]

$$\mu_{upper} = \frac{2}{3\,tr\,(\mathrm{cov}(x))} \quad (5.1)$$

$$\mu_{lower} = \frac{2}{tr\,(R_x)} \quad (5.2)$$

Where $tr\,(\mathrm{cov}(x))$ is the trace of covariance matrix. $tr(R_x)$ is trace of auto correlation matrix. The weight update equation in VED-NSS algorithm is given by

$$w(n+1) = w(n) + \frac{\mu(n+1)\,e(n)\,x(n)}{(\alpha_1\, e_s + ((1-\alpha_1))} \quad (5.3)$$

Where, α_1 is constant chosen for fast convergence, $\mu(n+1)$ is defined as in equation (3.4) and e_s is the normalized error given by

$$e_s = e^*(n)\,e(n) \quad (5.4)$$

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

$$\mu(n+1) = \mu_{upper} \qquad if \quad \mu(n+1) > \mu_{upper}$$
$$= \mu_{lower} \qquad if \quad \mu(n+1) < \mu_{lower}$$
$$= \mu(n+1) \qquad otherwisezz$$

6. Error Normalized Step Size (Enss)

ENSS algorithm is same as VED-NSS [8] except that the weight update consists of normalization of error vector. The weight updation in ENSS algorithm is given by

$$w(n+1) = w(n) + \left[\frac{\mu(n+1)}{(1+\mu(n+1)e_s(n))}\right] e(n)x(n) \quad (6.1)$$

III. Simulation Results:

Case1: Less Antenna Elements and Less Jammer with one desired angle Desired Angle=45 No.of Antenna=8.

Case2: more Antenna Elements and Single Jammer. Desired Angle=30 No.of Antenna Elements=100.

Case3: Less Antenna Elements and More Jammer. Desired Angle=45 No.of Antenna=8 Jammer Angle=5, 30, 60.

Case4: more Antenna Elements and MoreJammer. Desired Angle=30 No.of Antenna Elements=100 Jammer Angle=5, 10, 60.

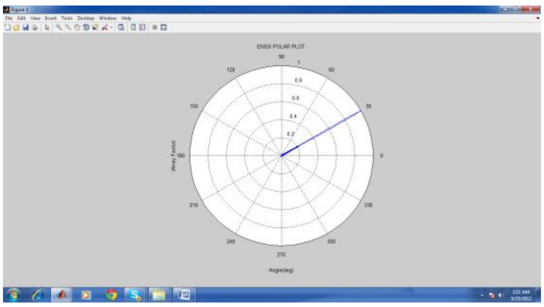

Fig 2: Polar plot of ENSS

which forms main beam at 30,while reducing jammers in non signal of interest (NSOI).

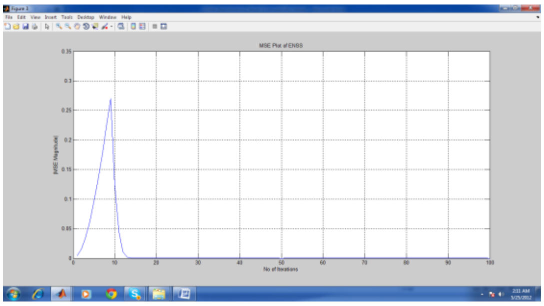

Fig3: MSE plot of ENSS

Converges at about 15iteration with less error compare to all other algorithms.

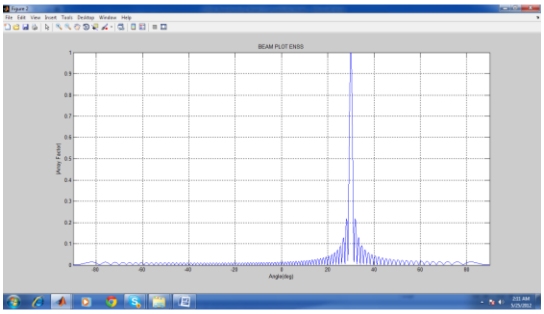

Fig4: Beam Plot with Desired Angle=30

Converges around 15 iterations whereas other algorithms converges about 100 iteration

Table: comparision of MSE Plots(100iterations)

	Case1	Case2	Case3	Case4
LMS converges	More than 100	More than 100	More than 100	More than 100
VSSLMS	Better than LMS	Better than LMS	Better than LMS	Better than LMS
Griffths	90	90	98	95
VSSG	Less error	Less error	Less error	Less error
EDNSS	better	better	better	Better
ENSS	40	15	40	15

I. Conclusion

In the phase the Beamforming algorithms namely; VSS,VSS-LMS,Griffiths,VSSG,VED were simulated and compared. These algorithms were able to produce main beam towards desired direction and direct nulls towards interference directions. The VSSLMS provides faster convergence as compared to LMS. The weight calculation is performed by varying the step size with an upper limit on the step size so that the algorithm does not diverge from the optimum value .The Griffiths' algorithm will use a constant step size and it requires knowledge of both autocorrelation and cross correlation. The VSSG algorithm combines the advantages of both VSSLMS and Griffiths' in order to improve convergence. Simulation result of beamforming algorithms showed that the convergence of VSSG is fast followed by Griffiths and VSS-VSSLMS.

References

[1] George V Tsoulos , "Smart antennas for mobile communication systems: Benefits and Challenges" , *IEEE proceedings of international conference on information technology*, Vol-11, Issue-2 ,pp 84-94.

[2] D. G. Manolakis, Vinay K Ingle and Stephen M Kogon, "Statistical and Adaptive Signal processing spectral estimation, signal modeling, Adaptive filtering and array processing," Mc Graw Hill 2000.

[3] Jack H. Winters , "Smart Antennas for Wireless Systems" **,** *proceedings of IEEE international conference on signal processing*, June 2005, pp 107-109.

[4] Okello, Y.Fukui, I.Nakanishi, Kobayashi, M "A New Modified Variable Step Size Algorithm for the VSSLMS algorithm", *IEEE Proceedings of the International Symposium on Circuits and Systems*, June 1998 , Vol 5,pp 170 – 173.

[5] L. C. Godara, "Application of antenna arrays to mobile communication. II. Beam-forming and direction-of-arrival considerations", *Proceedings of IEEE*, Vol 85, No 8, 1997, pp 1195-1245.

[6] Chen sun, Nemai Chandra Karmakar, "Direction of Arrival Estimation based on a Single-Port Smart Antenna using MUSIC Algorithm with periodic signals", *International Journal of Signal Processing*, 2004,Vol 1, No 2, pp153-162.

[7] Jeffrey Foutz, Andreas Spanias, and Mahesh K. Banavar, "Narrowband Direction of Arrival Estimation for Antenna Arrays", *Morgan & Claypool Publishers series*, 2008.

[8] Alexander D.Poularikas, Zayed M.Ramadan, "Adaptive iltering Primer with MATLAB", *CRC Press*, 2006.

[9] Lal Chand Godara, " smart antennas", *CRC press*, 2004.

[10] Frank B. Gross, " Smart Antennas for Wireless Communications", *McGraw-Hill*, 2005.

[11] Ahmed El Zooghby, "Smart Antenna Engineering", *Artech House mobile communications series*, 2005.

[12] Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, "Statistical and Adaptive Signal Processing", *ARTECH HOUSE publication, INC*, 2005.

[13] Nasser Kehtarnavaz, "Real-Time Digital Signal Processing Based on the TMS320C6000", *Newnes publishers*, 2005

[14] Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", *John Wiley and Sons*, 1966.

[15] Constantine A. Balanis, Panayiotis I. Ioannides, "Introduction to smart antenna", *Morgan & Claypool publishers*, 2007

[16] L.J Griffths, "A simple Adaptive algorithm for real time processing in Antenna arrays", *proceedings of IEEE*, Oct -1969, Vol-57.

[17] Kumaswamy .V,S.Ravishankar,"Implementation of Variable Step Size Griffths algorithm for beamforming ",Proccedings of IEEE International symposium on microwaves,2008,Vol-8,pp:31-35.

Website

[1] www.ti.com
[2] www.spectrumsignalprocessing.com