International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 1, Januaryr- 2013

Adaptive Array Beamforming using LMS Algorithm

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Abstract

Array processing involves manipulation of signals induced on various antenna elements. Its capabilities of steering nulls to reduce co channel interferences and pointing independent beams toward various mobiles, as well as its ability to provide estimates of directions of radiating sources, make it attractive to a mobile communications system designer. This paper presents 8-elements array with inter-element spacing $\lambda/2$ an optimum value to avoid grating lobes. An Adaptive beamforming is achieved by implementing LMS algorithm for directing the main beam towards the desired source signals and generating complex weights which can be used for obtaining narrow beam.

1. Introduction

Today's modern wireless mobile communications depend on adaptive smart antennas to provide maximum range and clarity. With the recent explosive growth of wireless applications, smart antenna technology has achieved widespread commercial and military applications [1], [2]. In principle, an antenna is smart antenna only when its DSP processor behind it is smart .Number of array elements are used for the design of smart antenna and can be modified to give different radiation pattern .The antenna array is a configuration of multiple antennas (elements) arranged to achieve a given radiation pattern and employs adaptive beamforming algorithms for recognize, track and suppress the interference. By combining the signals incident on the linear antenna array and by knowing their directions of arrival, a set of weights can be adjusted to optimize the radiation pattern. LMS algorithm used for adaptive beamforming is the simplicity and robustness algorithm and has become one of the most popular adaptive signal processing techniques adopted in many applications including antenna array beamforming. In adaptive beamforming, the radiation pattern of smart antenna is controlled through various adaptive algorithms. Adaptive algorithm dynamically optimizes the radiation pattern according to the changing electromagnetic environment. In this paper, analysis of adaptive techniques LMS, is done through matlab simulation by varying different parameters like Desired direction and Interference direction. Different complex weights are obtain using this LMS beamforming algorithm.

2. Array Weighting

Arrays of antennas are used to direct radiated power towards a desired angular sector. The number, geometrical arrangement, and relative amplitudes and phases of the array elements depend on the angular pattern that must be achieved. The array factor of a linear array is N (even) identical elements with uniform spacing. The combined relative amplitude and phase shift for each antenna is called a “complex weight”. These weights are calculated using different algorithms. After every iteration weights present in adaptive array are being updated .After the number of iteration the weights are obtain which gives the desired narrow beam.

3. LMS Algorithm

Least Mean Square algorithm is a method of stochastically implementing the steepest descent algorithm [3] .The LMS algorithm is the most widely used adaptive beamforming algorithm, being employed in several communication applications. The LMS based adaptive filter in which 'W' is the weight vector updated in accordance with the statistical nature of the input signal x (n) arriving from the antenna array. An adaptive processor will minimize the error e(n) between a desired signal d(n) and the array output y(n). An adaptive beam former consists of multiple antennas, complex weights (X1,X2…Xn-1), the function of which is to amplify or attenuate and delay the signals from each antenna element, and a summer to add all of the processed signals, in order to tune out the signals not of interest, while enhancing the signal of interest. Hence, beam forming is some time referred to as spatial directions are filtered out, while others are amplified. The output response of the uniform linear array is given by:

$$\text{Output, } y(n) = w^{h*} x(n) \ldots. (1)$$

the adaptive filter where the input signal x(n) is convolved by an unknown w(n) filter (to produce y(n)) which has an additive interference signal v(n) before being observed as d(n). The value of error signal estimation is

$$\text{Error } e(n) = d(n) - y(n) \ldots. (2)$$

The LMS changes the weight vector *w* (n) along the direction of the estimated gradient based on the steepest descent method. The weight vector updation for LMS algorithm is given by

$$w(n+1) = w(n) + \mu\, e(n)^* x(n) \ldots\ldots (3)$$

Where, μ is the step size [4].

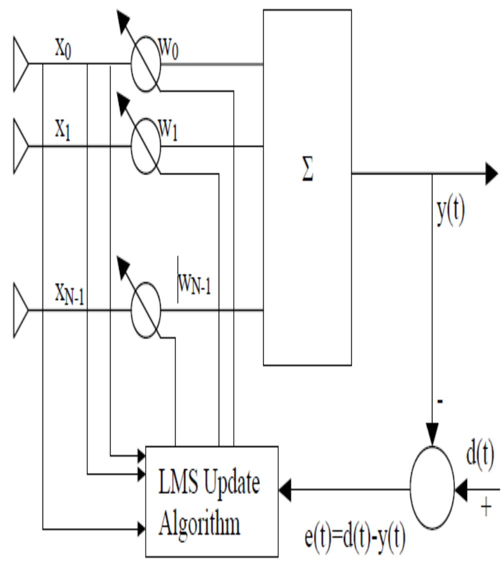

Figure 1. LMS Adaptive Beamforming Network

Mean Square Error (MSE) is increased with increase in step size and is decreased according to decrease in the step size [4].
To ensure convergence of the weight vector, the range of step size is given by [5].

$$0 < \mu < 1/\lambda_{max} \ldots.. (4)$$

4. Simulation Discussion

The performance of Beamforming algorithms has been studied by means of MATLAB simulation. In this simulation we have considered three cases with different look direction and interference which gives finest beam. For Simulation the following assumptions are considered

1. Mutual Coupling effects are zero between antenna elements.
2. Distance between antenna elements is λ/2 an optimum value to avoid grating lobes.
3. Number of array elements=8.

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Case (I)

Beamforming Result for LMS

Look Direction=-15 deg

Interference Directions= 3deg and 1deg

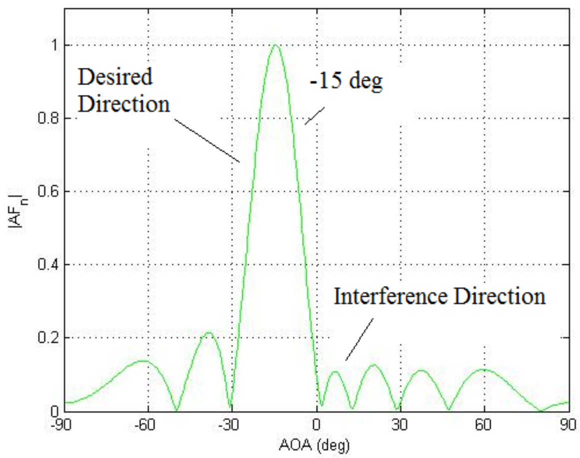

Figure 2. Beam Plot of LMS algorithm

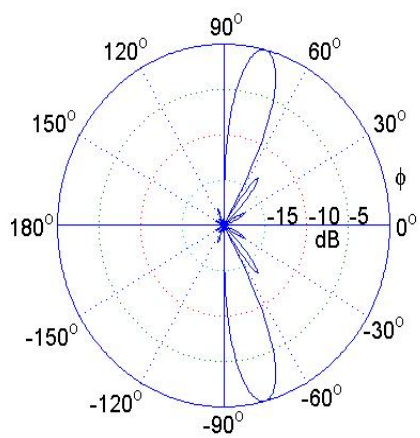

Figure 3. Spatial spectrum with 8 antennas

Weights:

w1 = 1

w2 = 0.6114-0.85746i

w3 = -0.26314-1.1717i

w4 = -1.0763-0.75749i

w5 = -1.3175+0.11514i

w6 = -0.83265+0.88971i

w7 = 0.07972+1.0718i

w8 = 0.85485+0.53832i

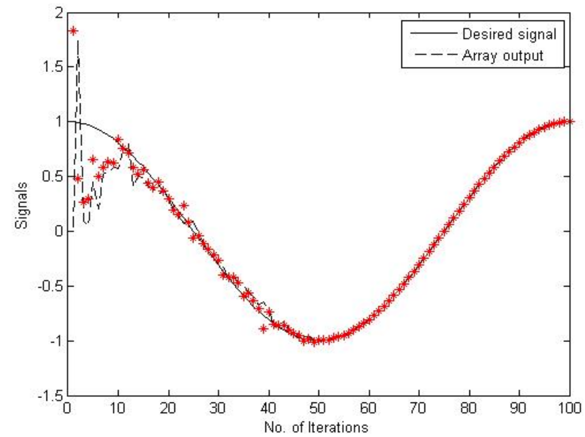

Figure 4. The simulation results set of eight elements array using LMS algorithm

Case (II)

Beamforming Result for LMS

Look Direction=10 deg

Interference Directions= -37deg and 32deg

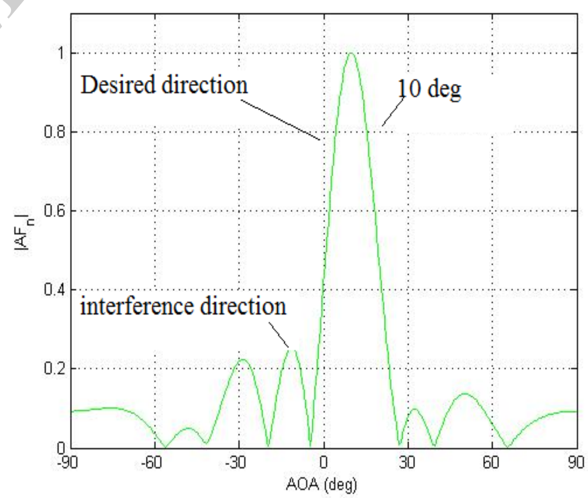

Figure 5. Beam Plot of LMS algorithm

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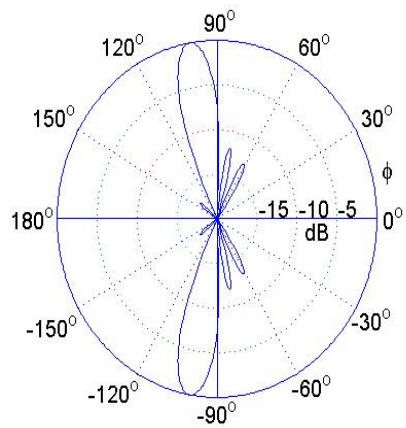

Figure 6. Spatial spectrum with 8 antennas

Weights:

w1= 1.0000
w2= 1.1351 + 0.3431i
w3= 0.8313 + 0.6698i
w4= 0.1233 + 1.3266i
w5= -0.4904 + 1.2709i
w6=-0.9583 + 0.4384i
w7=-1.1841 - 0.0066i
w8=-0.9872 - 0.2631i

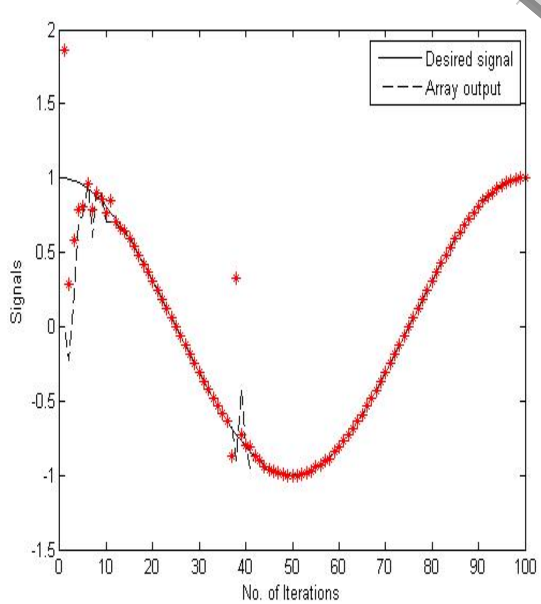

Figure 7. The simulation results set of eight elements array using LMS algorithm

Case (III)

Beamforming Result for LMS
Look Direction=35 deg
Interference Directions= 0deg and -20deg

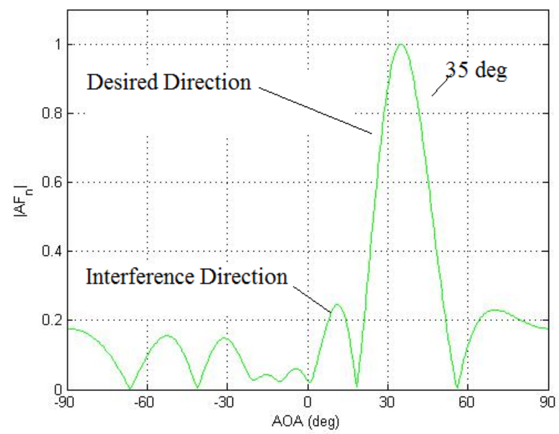

Figure 8. Beam plot of LMS algorithm

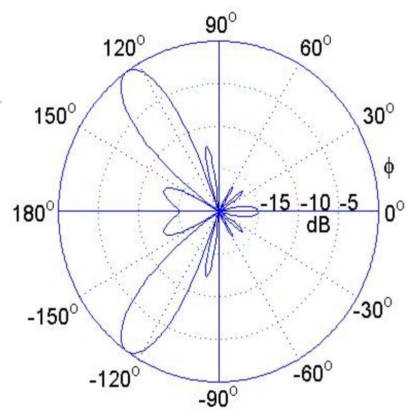

Figure 9. Spatial spectrum with 8 antennas

Weights:

w1 = 1
w2 = -0.56125+1.1955i
w3 = -1.1356-0.54929i
w4 = 0.84758-0.88914i
w5 = 0.63833+0.89851i
w6 = -1.2887+0.25558i
w7 = -0.35937-1.2805i
w8 = 1.0265+0.18895i

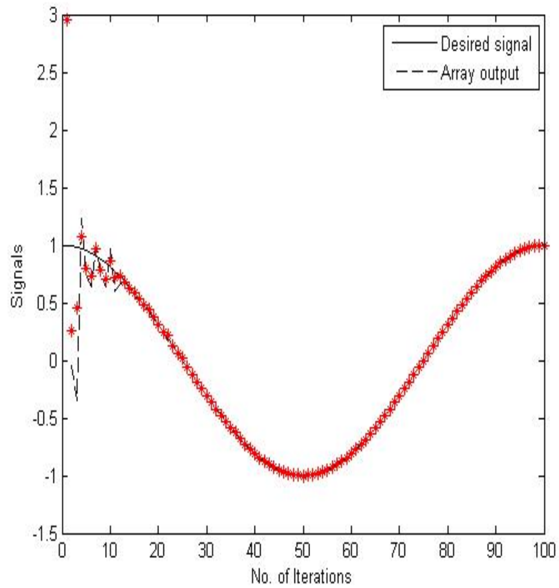

Figure 10. The simulation results set of eight elements array using LMS algorithm

Conclusion

A number of different cases have been observed keeping different look direction and interference direction. It is observed that these three cases give the best beam forming pattern using LMS algorithm. An approach has been accomplished to obtain complex weights through LMS algorithm. Further the weights obtain by LMS algorithm can be used for optimization of beamforming in the desired direction by steering the beam and reducing the interference by comparing the weights with the different algorithm.

Reference

[1] Balanis, C.A. (2005)," *Antenna Theory: analysis and design"*, New Jersey:John Wiley & Sons.

[2] Godara, L.C. (1997)," *Application of Antenna Arrays to Mobile Communications, Part II: Beamforming and Direction-of Arrival*",Considerations. Proceedings of IEEE, vol. 85, no. 8, pp. 1195-1245.

[3] G. B. Giannakis, "*Filterbanks for blind channel identification and equalization*", *IEEE* Signal Processing Lett., vol. 4, pp. 184–187, June 1997.

[4] B. Farhang-Boroujeny, "*Adaptive Filters Theory and Applications*", John Wiley & Sons, New York, 1998

[5] Byung Goo Choi, Yong Wan Park, Jeong Hee Choi , "*The Adaptive Least Mean Square Algorithm Using Several Step Size for Multiuser Detection*": Vehicular Technology Conference, 2000. IEEE-VTS Fall VTC 2000 52nd, vol 6, pp. 2822 - 2825, 2000.

[6] Freank Gross , "*Smart Antenna for wireless communication*"Mc Graw-hill, September 2005.

[7] Ibrahim A. H. Adam, MD. Rafiqul Islam, Othman O. Khalifa and AHM Zahirul Alam. "*Effects of Linear Array Antenna Parameters to the Performance of LMS Beamforming Algorithm*" The 7th International Conference on Robotics, Vision, Signal Processing, & Power Applications (RoViSP 2009). Langkawi

[8] Lal C. Godara, "*Application of antenna arrays to mobile communications, part II: beam-forming and direction-of-arrival considerations*", Proceeding of the IEEE, Vol. 85, No. 8, pp. 1195-1234, August 1997.