International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 09, September 2015
Available at http://internationaljournalofresearch.org

An Improved MUSIC DOA Estimation Algorithm for Wireless Communication

G. Yaminisasi[1]& K. Vasu Babu[2]
[1.]M.Tech Student of Vasireddy Venkatadri Institute of Technology Nambur AP-India,
[2]Assistant Professor, ECE Dept., Vasireddy Venkatadri Institute of Technology Nambur ,AP-India
Mail: yamini.guntamukkala@gmail.com[1]; vasubabuece@gmail.com[2]

Abstract:

Mainly smart antenna depends upon digital signal processing algorithms. It has the ability to discover and detect signals by both its sender and receiver along with interferer and it actively alter the antenna pattern to strengthen the receiving capability in the direction in which we are desiring to send the signal and it also reduce the intervention in the direction of not interest direction. The accomplishment of the smart antenna system is greatly based on the performance of digital signal algorithms. Basically in adaptive array smart antenna to detect the desired signal there are a number of DOA estimation algorithms. The numbers of incident plane waves on the antenna array along with their angle of incidence are estimated by using these algorithms. This paper helps to determine the peaks of MUSIC algorithm for coherent signals in a new way.

Key words: Smart antenna; MUSIC algorithm; Direction of Arrival

I.INTRODUCTION

Smart Antenna systems have been long predicted to provide much better performance than existing antennas in terms of power consumption, user capacity and noise suppression. In fact, antennas are not smart, antenna systems are smart. Smart antenna system is nothing but an antenna array when combines with a digital signal processor, so that it's main function is to transmit and receive signals in an adaptive, spatially sensitive manner.

It has the capacity to find and trace signals from both senders and receivers and mainly the radiation pattern in this system is changed by modifying the amplitude and relative phase of the different elements. It can automatically alter the directionality of the radiation pattern in according to the signal environment.

Because of smart antenna technology there is a considerable progress in the performance of the wireless communication in terms of quality, capacity and also in the area that particular base station is going to cover. Even though it is a new technology basically the performance is limited by two major impairments which are nothing but the multipath and co-channel interference.

Two basic types of smart antennas are Adaptive and Switched antenna arrays. In Adaptive antenna system, in order to enhance the signal in desired direction, Direction of Arrival (DOA) algorithms are used. Accurate estimation of Direction of Arrival (DOA) from a source has received a lot of attention in both civilian and military applications such as seismology, search and rescue, sonar and law enforcement.

The estimation in fact is most difficult because there are usually enormous number of signals impinging on the array simultaneously definitely from unknown directions and unknown amplitudes. Another issue that is to considered is the received signals are also corrupted by noise. The several DOA estimation algorithms are Barlett, Capon Min-norm, MUSIC and ESPIRIT.

In this paper a detailed simulation result for coherent signals in MUSIC algorithm in MATLAB is going to be studied.

II. DOA ESTIMATION ALGORITMS

DOA estimation uses antenna arrays instead of single antenna. By using an antenna array system in DOA estimation the resolution of the received signals will be high (Resolution here is the capability to differentiate two different signals arriving at different signals).

DOA estimation algorithms are divided into three different techniques namely; Conventional methods, subspace methods and maximum likelihood methods. Conventional methods mainly depends upon the concepts of null steering an beam forming but in order to provide high resolution it requires large number of elements. Capon's minimum variance method and delay and sum method comes under this category. But subspace methods results in a high resolution and gives the information of the incident signals and DOA of each signal. MUSIC and ESPIRIT algorithms are thus widely used.

Maximum likelihood is the first method for DOA estimation but the major limitation in this technique is its computational complexity.

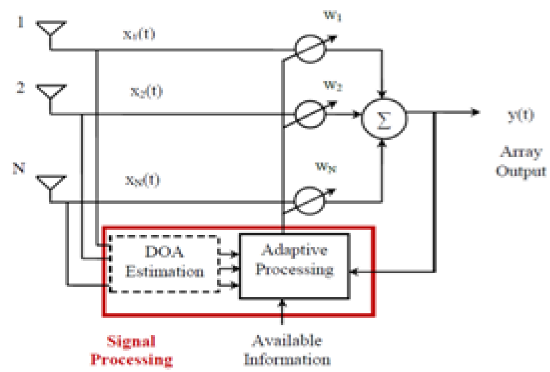

Fig 1: Block diagram of Smart Antenna System

The figure above shown is the Antenna system in which the beam pattern is changed by the internal feedback control while it is operating. The direction of interferers and the users can be obtained by DOA estimation algorithms.

III. MUSIC ALGORITHM

The acronym for MUSIC algorithm is Multiple Signal Classification and it was proposed by Schmidt in the year 1979. It is a sub spaced DOA estimation algorithm and it is a high resolution technique gives the information about the number of signals arrived and their direction of arrival.

It depends upon the concept of Eigen decomposition of the covariance matrix which resolves it into two orthogonal matrices i.e., signal and noise subspace. Assumption here is that source and noise are both uncorrelated.

Assume that a system consist of uniform linear array with N-elements and M-sources and the distance between the elements is 'd' and in the array the first element is considered as the reference element.

International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 09, September 2015
Available at http://internationaljournalofresearch.org

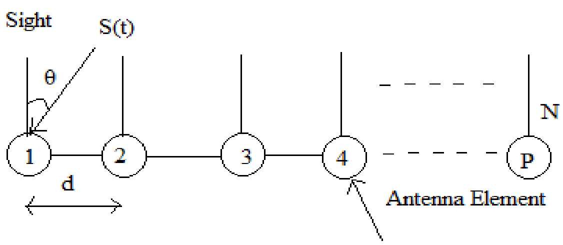

Fig 2 : Uniform linear array and DOA

From the figure it is clear that the data received at the array antenna is

$$X=AS+n$$

Where $A = [a(\theta_1), a(\theta_2), a(\theta_3),\ldots\ldots. a(\theta_M)]$: Array steering vector 1S = Signal source and n is an additive noise term whose mean is 0 and variance is σ^2.

The autocorrelation matrix of the received signal can be

$$R_{xx} = E\,[XX^H]$$

Where 'E' is expectation operator

$[.]^H$ is a complex conjugate transpose.

And finally the auto correlation matrix of the received vector can be written as

$$R = E\,[XX^H]$$

$$= E\,[(AS+n)\,(AS+n)^H]$$

$$= AVA^H + \sigma^2 I$$

$$= R_S + \sigma^2 I$$

Where σ^2 is a variance of white Gaussian noise vector, V is covariance matrix of signal vector, R_S is a signal covariance matrix.

It is already clear that signal subspace and noise subspace are orthogonal. Let μ_m be such an eigen vector. Then

$$R_S\,\mu_m = AVA^H\,\mu_m = 0$$

Since V is a positive e definite matrix,

$$A^H\,\mu_m = 0$$

$$a^H(\theta_i)\,\mu_m = 0$$

This implies that signal steering vectors are orthogonal to eigen vector corresponding to noise subspace.

So the MUSIC algorithm searches through all angles and plots the spatial spectrum

$$P_{MUSIC}\,(\theta) = \frac{1}{a^H(\theta i)\mu m}$$

Whenever θ is in a signal direction, the denominator of the above equation becomes zero. Hence, the estimated signal directions will yield M largest peaks in the spectrum and peak direction will give spatial angles of all incident signal sources.

IV.IMPROVED MUSIC ALGORITHM

Theoretically, it is clear that the MUSIC algorithm attains full resolution but it is constrained to uncorrelated signals. When considering a signal with a low SNR and a correlated signal the performance is very dull or even it is deteriorated. For this we are going to introduce improved MUSIC algorithm which is possible by conjugate reconstruction of data matrix of MUSIC algorithm.

Make a transformation matrix J, J is an M^{th}-order anti-matrix, known as the transition matrix, i.e.

International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 09, September 2015
Available at http://internationaljournalofresearch.org

$$J = \begin{matrix} 0 & 0 \ldots & 1 \\ 0 & 0 \cdots & 0 \\ 1 & 0 \ldots & 0 \end{matrix}$$

let Y=JX*, where X* is the complex conjugate of X, then the covariance of data matrix Y is

$$R_y = E\,[YY^H] = JR_x{}^*J.$$

From the sum of Rx and Ry, the reconstructed conjugate matrix can be obtained.

$R = R_x + R_y = ARsA^H + J\,[ARsA^H]^*J + 2\sigma^2 I$

According to matrix theory, the matrices Rx, Ry and R have the same noise subspace. To conduct characteristic decomposition of R and get its eigen value and eigenvector, according to the estimated number of signal source, separate the noise subspace, and then use this new noise subspace to construct spatial spectrum and obtain the estimated DOA value by finding the peak.

IV. SIMULATION RESULTS

When the signals are coherent, let the incident angle is 20^0 and 60^0 respectively, those two signals are not correlated, the noise is ideal Gaussian white noise, the SNR is 20dB, the element spacing is half of the input signal wavelength, array element number is 10, and the number of snapshots is 200. The simulation results are shown in the figure 3.

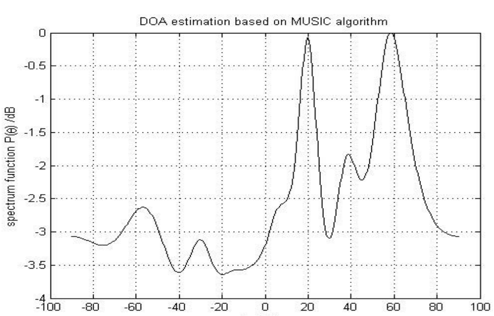

Fig 3: Simulation for MUSIC algorithm when the signals are coherent

In case of improved MUSIC algorithm the simulation result is shown in the figure 4.

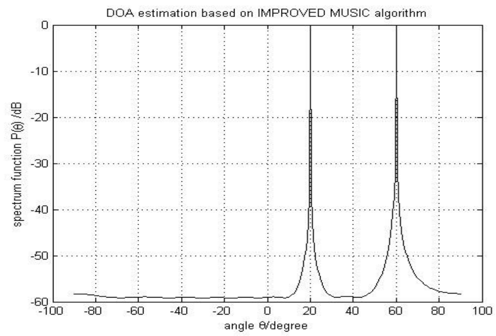

Fig 4: Simulation for Improved MUSIC algorithm when the signals are coherent

V. CONCLUSION

In this paper it is clear that MUSIC algorithm is a high resolution technique for DOA estimation with the increase in number of elements, snapshots and SNR. For low SNR and small incident angle difference the performance is much not better. These problems made MUSIC algorithm a hot research topic. So it has a much room for development, and it also worth further study.

VI.REFERENCES

[1] Peter Stonica etc. MUSIC Maximum Likelihood and Cramer-Rao Bond, IEEE Trans on ASSP. 1989. Vol. 37(5). P720~741.

[2] Zhang XF, Chen C, Li JF, Xu DZ. Blind DOA and Polarization Estimation for Polarization-sensitive Array using Dimension Reduction MUSIC. Multidimensional Systems and Signal Processing. Jan, 2014, 25-1. P67~82.

[3] E. Tuncer and B. Friedlander, "Classical and Modern Direction-of- Arrival Estimation," Ed. Elsevier, USA, 2009.

[4] Fuli Richard. Analysis of Min-norm and MUSIC with Arbitrary Array Geometry. IEEE Trans on AES.1990. Vol. 26(6). P976~985.

[5] Michael L. Miller. Maximum Likelihood Narrow-band Direction Finding and EM Algorithms. IEEE Trans on ASSP. 1990. Vol. 36(10). P1560~1577.

[6] R, Roy. and T. Kailath, ESPRIT "estimation of signal parameters via rotational invariance techniques," IEEE Trans. Acoust., Speech, Signal Process., Vol. 37, No. 7, Jul. 1989.

[7] P. Yang, F. Yang, and Z.-P. Nie, "DOA estimation with sub-array divided technique and interpolated esprit algorithm on a cylindrical conformal array antenna," Progress In Electromagnetics Research, Vol. 103, 201-216, 2010.

[8] B. Liao, S.C. Chan, "DOA Estimation of Coherent Signals for Uniform Linear Arrays with Mutual Coupling," Symposium on Circuits and Systems (ISCAS), 2011 IEEE International, May 2011, Rio de Janeiro, Brazil.

[9] J. A. Cadzow, "Signal enhancement-A composite property mapping algorithm," IEEE Transactions on Acoustics, Speech, and Signal Processing, vol. 36, pp. 49-62, January 1988.

[10] J.-J. Fuchs, "On the application of the global matched filter to DOA estimation with uniform circular arrays," IEEE Trans. Signal Processing, vol. 49, Apr. 2001, pp.702-709.