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STUDY OF ESTIMATION OF DIRECTION OF ARRIVAL FOR TRANSMITTER ARRANGEMENT IN WIRELESS MOBILE COMMUNICATION

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Abstract

The demand of mobile communications services is keep on growing day by day, with the anticipation that communication to a mobile device is possible at anytime, anywhere without any distortions and delay on the globe. The demand is going to be at its peak as new technology like IOTs came in picture. The smart city, smart home, smart banking etc. will require mobile connectivity and accessibility. On other hand the resources for communication systems like channel bandwidth for mobile communication, space, area etc. are fixed, noises and distortion increasing with increase in number of communication devices. Therefore, researches have been happening in wide areas related to pervasive mobile communication. The estimation of direction of arrival of signals for antenna system is one of the concern problems for research. This paper presents the study of estimation of direction of arrival using "Estimation of Signal Parameters via Rotational Invariance Technique"(ESPRIT) method on adaptive antenna arrays. The main objective of using the **ESPRIT** technique is to exploit the rotational invariance (RI) in the signal subspace and compare the results with the results of MUSIC method [1] so that antenna arrangement system can be configured efficiently.

Keywords: *DOA, ESPRIT, AAA, RIT, MUSIC, TIS*

Introduction

The grown demand for mobile communication channels, users and affordable services enforce the operators to support more users per base station. This reduces the overall network cost and results in requirements of higher data rates and higher capabilities per base station. Unfortunately, the available broadcast spectrum is limited; so attempts to increase traffic within a fixed bandwidth create more interference in the system and degrade the signal quality. The use of isotropic antenna at base stations as a transceiver system works as a source of interference to other users located in the same cell, making the overall system interference limited.

The adaptive signal processing arrays sensor, known as Adaptive Antenna Arrays or Smart Antennas, have been adopted on very large scale for mobile communication system.Its ability to locate mobile users through DOA detection techniques makes it more popular antenna system for wireless mobile communication. The estimation of location of mobile users facilitates the mobile equipment or the base station to enable transmissions patterns accordingly. Adaptive antenna arrays also improve the performance of cellular systems by providing robustness against fading channels and reduced collateral interference [2].

The goal of direction-of-arrival (DOA) estimation is to utilize the data received through the downlink channel at adaptive antenna to estimate the directions of the desired mobile users as well as the directions of interference signals. The results of DOA estimation are then used by base station control unit to adjust the weights of the adaptive antenna system so that the radiated power is maximized towards the desired users, and radiation nulls are to be placed in the directions of interference signals. Hence, a powerful design of an adaptive array highly depends on the choice of the DOA estimation algorithm. This dependency opens doors for researchers, academicians to investigate and find solution for the highly accurate and robust estimation system.

Transmitter Arrangement

The Estimation of Signal Parameters via Rotational Invariance Technique (ESPRIT) was developed by Roy and Kailath in 1989 [3]. It is based on the rotational invariance property of the signal space to make a direct estimation of the DOA and obtain the angles of arrival without the calculation of a pseudo spectrum on the extent of space, nor even the search for roots of a polynomial. This method explores the property of translational invariance of the antenna array by decomposing the main network into two sub-networks of identical antennas which one can be obtained by a translation of the other, Figure 1.

It is assumed thatantenna elements are arranged uniformly with linear spacing and ignoring mutual coupling between elements and also assume that the element patterns of the arrangement transmitter are identical [4]. It is also considered that incident waves are narrow band plane waves W, where the center wavelength is λ, and the observed a linear arrangement of transmitter consists with separation of d units (unit is same as λ).

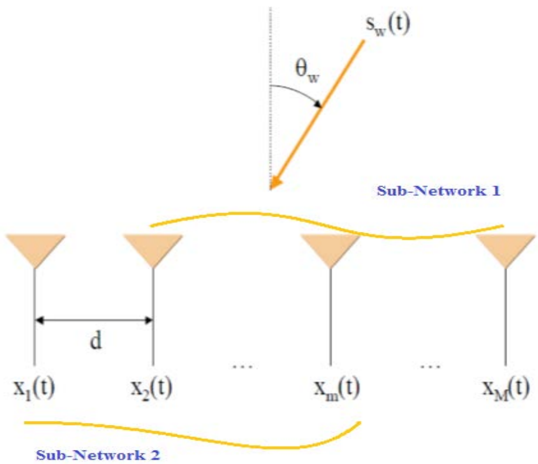

Figure 1: Antenna Array Arrangement

The output signal of the m^{th} element then be described as

$$\boldsymbol{x}_m(t) = \sum_{w=1}^{W} \boldsymbol{s}_w(t) . \boldsymbol{a}_m(\theta_w) + \boldsymbol{n}_m(t) \text{-------}(1)$$

$$\boldsymbol{a}_m(\theta_m) = e^{j2\pi \frac{f}{c} d(m-1)\sin\theta},$$

$$\boldsymbol{a}_m(\theta_m) = e^{j2\pi \frac{1}{\lambda} d(m-1)\sin\theta} \qquad \text{--------------}(2)$$

; m = 1, 2, 3, ………… M

Where$\boldsymbol{s}_w(t)$and $\theta_w$are the complex amplitude and DOA of thew^{th} source, in that order, the vertical direction in terms of the arrangement system is assumed to be 0°, $\boldsymbol{n}_m(t)$ is the normally distributed noise with mean "0" and variance σ^2, f is the carrier frequency, and c is the speed of light. Equation (1) can also be expressed in generic vector form as

$$\boldsymbol{x}_m(t) = \boldsymbol{AS}(t) + \boldsymbol{n}_m(t) \text{----------------} \qquad (3),$$

$$\boldsymbol{X}(t) = [x_1(t) \;\; x_2(t) \;\; x_3(t) .. \; x_M(t)] \text{ -----------} (4),$$

A = $[a(\theta_1) \;\; a(\theta_2) \;\; a(\theta_3) \dots\dots \; a(\theta_w)]$ --- (5),

$$a(\theta_w) = [1 \;\; e^{j\frac{2\pi}{\lambda} d\sin\theta} \, e^{j\frac{2\pi}{\lambda} 2d\sin\theta} \; \dots\dots . \, e^{j\frac{2\pi}{\lambda}(m-1)d\sin\theta}]^T \text{----}(6),$$

$$\boldsymbol{S}(t) = [s_1(t) s_1(t) s_1(t) \quad \dots\dots\dots \;\; s_1(t)] \text{ ----------}(7),$$

&

$$\boldsymbol{n}(t) = [n_1(t) \;\; n_2(t) \;\; n_3(t) \;\; \dots\dots\dots \;\; n_M(t)] \;\; \dots\dots(8)$$

Where "[ ]ᵀ" represents the transpose of a matrix, $a(\theta_w)$represents the "steering vector", which shows the characteristics of the transmitter array arrangement for the direction of θ_w [5].

Then, the arrangement correlation matrix is defined as

$$\boldsymbol{R}_{xx} = E[\boldsymbol{X(t)X^H(t)}] \text{------------------------------------}(9)$$

Similarly, $\boldsymbol{R}_{yy} = E[\boldsymbol{Y(t)Y^H(t)}]$------------------- (10)

ESPRIT Algorithm for DOA estimation

It also assumed that signals induced on the m^{th}pair due to a narrow band source in direction ɵ be denoted by $x_{m-1}(t)$ and $x_m(t)$,respectively. The phase difference [6] between the two signals depends upon the time taken by plane waves arriving from the source under consideration to travel from one element to the other. As the two elements are separated by the displacement$d$, it will follow the expression as

$$x_m(t) = x_{m-1}(t) e^{j\frac{2\pi}{\lambda} d\,\sin\theta} \text{------------} \qquad (11)$$

The signals received by the two arrays be denoted by$x_{m-1}(t)$ and $x_m(t)$.This is expressed as

$$x_{m-1}(t) = A\phi s(t) + n_{m-1}(t) \text{----------} \qquad (12)$$

$x_m(t) = A\phi s(t) + n_m(t)$---------------- (13)

Where,*A*is*K*x*M* matrix, with its columns as*M*steering vectors corresponding to *M*directional sources associated with the first sub-array;ϕ is an*M*x*M* diagonal matrix, provides the phase shift in translation of arrived signals, with itsm^{th}diagonal element given by

$\phi_{mm} = e^{j\frac{2\pi}{\lambda}(m-1)d \sin\theta_m}$----------------- (14)

Comparing the equations 12 and 13, it is found that the steering vectors corresponding to *M* directional sources associated with the second sub-array are given by$A\phi$.

IfU_x and U_y bethe two *K*x*M* matrixes with their columns represent*M* eigenvectors corresponding to the largest eigenvalues of the two array correlation matrixes R_{xx} andR_{yy} , respectively. As these two sets of eigenvectors span the same *M*-dimensional signal space, it follows that the two matrixesU_x and U_y are related by a unique nonsingular transformation matrix Ψ, so

$U_x \Psi = U_y$--------------------- (15)

Similarly, these matrixes are related to steering vector matrixes $A$and $A\phi$by another unique nonsingular transformation matrix T, as the same signal subspace is spanned by them. Therefore,

$U_x = AT$------------------------- (16),

&

$U_x = A\phi T$-------------------- (17)

Substituting for U_x and $U_y$and the fact that A is of full rank, it is obtained

$T\Psi T^{-1} = \phi$-------------------- (18)

It states that the eigenvalues of Ψ are equal to the diagonal elements of $\phi$and the columns of T are eigenvectors ofΨ. This is the main relationship developedunder ESPRIT method [7]. It requires an estimate of Ψ from the measurement$x_{m-1}(t)$and$x_m(t)$.

Aneigendecomposition of Ψprovidesthe eigenvalues, and by equating them toϕ leads to the direction of arrival estimates. It can be expressed by

$\theta_m = \sin^{-1}\{\frac{\lambda_m * arg(a_m)}{2\pi d}\}$; m = 1, 2, 3,…….., M ----(19)

Simulation Results

MATLAB tool has been used for the simulation of ESPRIT algorithm of DOA estimation techniques. The parameters used and their values of the simulations are listed below in the table.

Table 1: Parameters Set for SPRIT algorithms

Parameters	**Value**
Angle of Arrival of Signals	25°, 80°
Inter Element Spacing (d)	$\frac{\lambda}{2}$
Number of Elements in an Array	8,16
SNR Range(dB)	0,25
Number of Snapshots	200, 1000

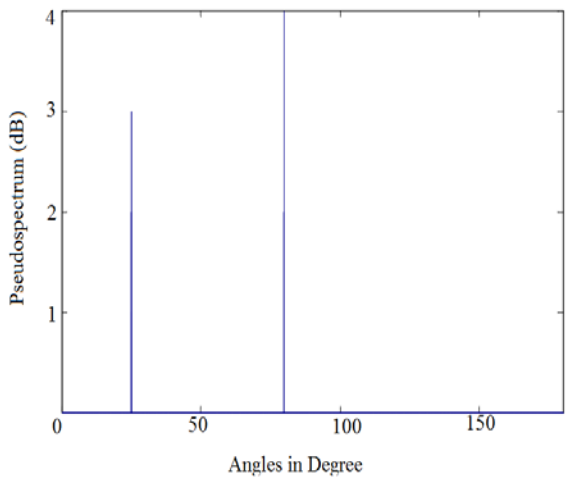

Figure 2: ESPRIT spectrum for array elements 8 and 16. (SNR= 25 db and number of snapshots = 200)

ESPRIT spectrum provides almost similar DOA estimates for different array elements with lesser variance than MUSIC algorithm

Table 2: DOA with variation in number of elements in Antenna Array

Actual DOA	Estimated DOA	
	Array Elements = 8	Array Elements = 16
25°	25.003°	25.001°
80°	79.95°	79.98°

ESPRIT technique has been tested for two different SNR values 0dB and 25dB

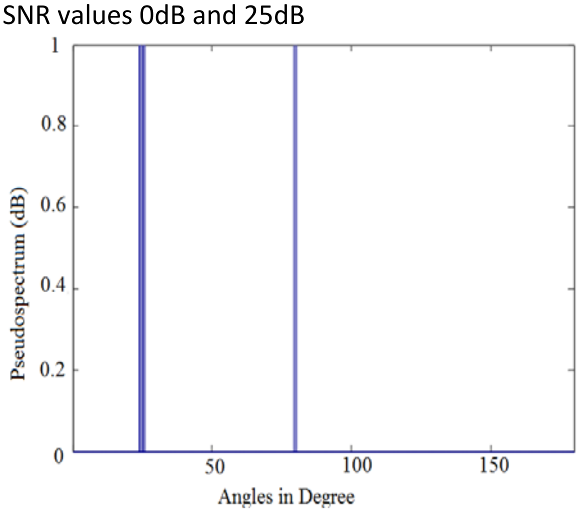

Figure 3: ESPRIT spectrums for SNR of 0dB and 25dB.

(Number of array elements = 8 and number of snapshots =200)

Pseudo spectrum obtained using ESPRIT technique for different S.N.R values is shown in Figure 3 and their DOA estimates are shown in Table 3.

Table 3: DOA estimation for SNR 0dB and 25dB

Actual DOA	Estimated DOA	
	SNR = 0 dB	SNR = 25 dB
25°	24.92°	24.97°
80°	79.1°	80.00°

Conclusion

The paper represents analysis of ESPRIT method for arrangement of antenna array or one can say arrangement of transmitter system for achieving better direction of arrival resolutions. In the reference paper the MUSIC method of DOA estimation has already been performed and hence the ESPRIT method had to be tested for the same. The result shows somewhat improvement over MUSIC method at same SNR and antenna array system. It has been found that there is very less impact of number of elements in antenna array if it is less in numbers with ESPRIT methodwhile it was reported the estimation approached the actual DOA if number of elements increased in MUSIC method. The analysis also shows that ESPRIT does not involve the exhaustive search of all possible steering vectors to estimate DOA and hence dramatically reduces the computational and storage requirements as compared to MUSIC method of estimation of direction of arrival.From the simulated results, it is observed that ESPRIT provides an accurate estimation of. But in the case of diversely polarized antenna arrays where the SNR values and number of snapshots are less this algorithms failed to achieve precise estimation of DOA of signals.

References

1. Manish Kumar Goyal, and Prof. PuranGour“An Evaluation of the Arrangement Transmitter System by Direction of Arrival (DOA) Estimation”,

International Journal Of Engineering And Computer Science ISSN:2319-7242 Volume - 3 Issue - 8 August, 2014 Page No. 7646-7652.

2. M. A. Al-Nuaimi, R. M. Shubair, and K. O. Al-Midfa "Direction of arrival estimation in wireless mobile communications using minimum veriancedistorsionless response", The Second International Conference on Innovations in Information Technology, 2005.
3. Richard Roy and Thomas Kailath, "ESPRIT-Estimation of signal parameters via rotational invariance techniques," IEEE Transactions on Acoustics, Speech, and Signal Processing, vol. 37, N° 7, pp. 984-995, July 1989.
4. C.A. Balanis, A.S. Spania, T.M.Duman and Capone, J.M., "Impact of smart antenna designs on network throughput and BER", Antennas and Propagation Society International Symposium, 2004
5. Constantine A. Balanis, Antenna Theory: Analysis and Design, Wiley-Interscience, 2005.
6. Mohammad J. Mismar1 and Taiseer H. Ismail2, "DOA and Power Estimation by Controlling the Roots of the Antenna Array Polynomial", Progress In Electromagnetics Research M, Vol. 46, 193–201, 2016
7. J. Weiss and M. Gavish, "Direction finding using ESPRIT with interpolated arrays," IEEE Trans. Signal Processing, vol. 39, pp. 1473–1478, 1991