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Direction of Arrival Estimation for Closely Spaced Signal

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ABSTRACT: High resolution direction of arrival estimation algorithms based on the subspace decomposition received considerable attention while rarely used in the practical applications. The reasons is its difficulty to resolve closely spaced signals in low SNR. For applications of closely spaced signals within a priori known angle range, we filter the spectrum in direction domain to improve the SNR of signals on array sensors and reconstruct the covariance matrix with which Multiple signal classification algorithm is applied. The improvement in the aspects of resolution and accuracy in low SNR is shown by Monte-Carlo simulations. The spatial spectrum expresses signal distribution in the space from all directions to the receiver. Hence, if one can get the signal's spatial spectrum, then the direction of arrival can be obtained.

KEYWORDS: Direction-of-Arrival, SNR.

I. INTRODUCTION

Direction-of-Arrival (DOA) estimation plays a vital role in many applications. The problem of estimating the wave number or angle of arrival of a plane wave is referred to as direction finding or DOA estimation problem. It has a large application in radar, sonar, seismic systems, electronic surveillance, medical diagnosis and treatment, radio astrology and other areas. Estimating directions of interesting targets is an important task in the area of electronic countermeasure. The so-called high resolution methods such as MUSIC and ESPRIT can break through the Rayleigh limit and are thereby widely researched. Direction-of-arrival (DOA) estimation for highly correlated signals is of great importance in multipath environments such as low-elevation altitude measurement.

SMART antennas have been widely used in many applications such as radar, sonar, and communication systems. The performance of smart antennas relies heavily on the accurate estimation of the direction of arrival (DOA) of each signal, and various techniques for DOA estimation have been proposed the most commonly used techniques are multiple signal classification (MUSIC), estimation of signal parameters via rotational invariance technique (ESPRIT), and their variations.

Evaluating directions of interesting targets is an important task in the area of electronic countermeasure. The supposed high determination techniques, for example, MUSIC and ESPRIT can get through as far as possible. Additionally enhancing the determination of the techniques for nearly separated signs is a testing work. High-determination DOA estimation calculations, for example, MUSIC and ESPRIT are great if there should arise an occurrence of different impinging signs of a similar time and a similar recurrence. Then again, these high-determination DOA estimation calculations can barely work when the SNR is low, the number of sensors or the quantity of depictions is few, or particularly at the point when the signs are firmly dispersed in headings

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II. LITERATURE SURVEY

In literature, the problem and the previous techniques of DOA estimation is described.
Z. Y. Song, et.al [1] the amplitude fluctuation characteristic for got echoes contains the sign data about the many-sided quality of targets which being inside the radar pillar. In this paper the conditional probability density functions of the measured amplitude and observed SNR of received echoes are developed..[1]
Y. S. Zhouet.al [2] this paper presented the jamming principle of the TRAD quickly. The needed equivalent transmitting power, the length of the cable and the off-target distance are analyzed [2]

R. O. Schmidt et.al [3] As this paper, the works of Gething and, Davies were found, offering a piece of the arrangement talked about here however as far as synchronous conditions and exceptional straight connections without response to eigen structure.[3]

N. Y. Wanget.al [4] Another DOA estimation strategy in view of subarraybeamforming has been proposed. In the new strategy, two subarray beamformers are utilized to get an ideal estimation of the stage moved reference flag whose stage in respect to the reference flag is an element of the target DOA.[4]

III. PROPOSED SYSTEM

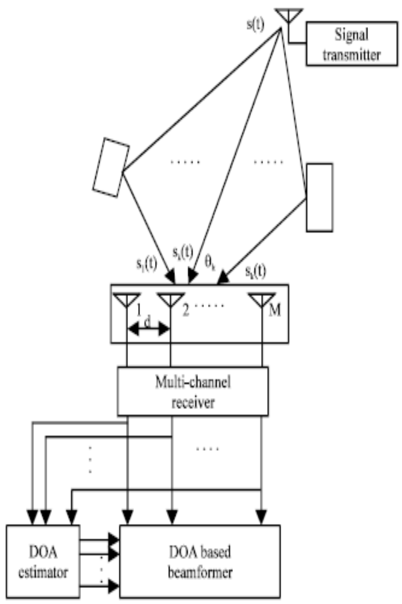

Fig1 : Block diagram of DOA using MUSIC

A smart antenna composed of various antenna sensors, whose signal is diagnosed automatically in order to use the mobile radio channel's spatial domain. By locating the main beam in the user direction and forming nulls towards the interference signal direction, smart antennas can provide higher signal-to-noise ratio (SNR), minimum co-channel interference and multipath fading with higher the system capacities in mobile network. The main objective of direction of arrival (DOA) estimation is to use the information received by antenna array elements to determine the directions of the signals from the users as well as the directions of interference signals. Some of the DOA estimation algorithms are

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delay-and-sum method, Capon's minimum variance technique, multiple signal classification (MUSIC) algorithms, estimation of signal parameter via rotational invariance technique (ESPRIT). The DOA algorithm considering SNR is also reported. The target of DOA estimation techniques is to plot a pseudo spectrum, by searching the peak to find the angle of arrival of signal. Among different DOA estimation utilized algorithms, MUSIC algorithm is depended on decomposition of received signal's covariance matrix and has good estimation accuracy and reduced complexity of system as compared to other DOA algorithms. Due to decomposition of received signal's covariance matrix, it is partitioned into two subspace matrices such as signal subspace and noise subspace. MUSIC algorithm gives appropriate impinging signal direction and more stable resolution compared to ESPRIT. The high resolution of direction of arrival has achieved by MUSIC algorithm in case of non-coherent or uncorrelated signal. The effectiveness of MUSIC is lost for AOA estimation of correlated or coherent signal.

VI. SIGNAL MODELING

Assume Dstatistically independent narrowbandfield signals are impinge on a linear array composed of M identical omni-directional sensors spaced by half wavelength. The signal number D is assume to be known or to be obtained by estimation. The superscript "*", "T" and "H" denote the conjugate, the transpose and the conjugate transpose, respectively. The outputs of the M array elements at time t are arranged in an M ×1 vector

$x(t) = [x_1(t), x_2(t), \cdots, x_M(t)]^T = As(t) + n(t)$ (1)

Where $s(t) = [s_1(t), s_2(t), \cdots, s_D(t)]^T$ is the signal vector, $n(t) = [n_1(t), n_2(t), \cdots, n_M(t)]^T$ is the noise vector, $A = [a(\theta_1), a(\theta_2), \cdots a(\theta_D)]$ is the steering matrix, $\theta_1, \theta_2, \cdots, \theta_D$ are directions of the signals relative to the array. Supposed $\theta_1 < \theta_2 <, \cdots, < \theta_D$ without loss of generality, the steering denoted as $a(\theta)[e^{-i\frac{2x}{\lambda}d_1}\sin\theta \cdots e^{-i\frac{2x}{\lambda}d_M}\sin\theta]^T$ (2)

Where λ is the wavelength and d_i(0 <I <M) is the position of sensor i (assuming that the first sensor locates at the origin. We assume that $s_1(t)(i = 1,2, \cdots, D)$ is zero-mean stationary random process with the variance $\sigma^2_{s,i}$ that $n_i(t)$ is the complex circular Gaussian white noise with the variance $\sigma^2_{s,i}$, and that the signals and noises are statistically independent

V. CLASSICAL MUSIC ALGORITHM

The MUSIC algorithm is classical algorithm based on the eigen decomposition. The "spectrum" of MUSIC can be plotted by the orthogonality between the signal subspace and the noise subspace. The following is the processes of MUSIC . The first step is to compute the covariance matrix of the array outputs.

$$R_{xx} = E\{x(t)x^H(t)\} = AR_{ss}A^H + \sigma_n^2 I \quad (3)$$

Where R_{xx} is the signal covariance matrix, and $\sigma_n^2 I$ is the noise covariance matrix. The second step is to decompose R_{xx} as follows

$$R_{xx} = \sum_{i=1}^{M} \propto_i u_i u_i^n = s \wedge s^H + \sigma_n^2 G G^n \quad (4)$$

Where $s = [u_1, u_2, \cdots u_D]$ spanned the signal subspace,

$G = [u_{D+1}, u_{D+2}, \cdots u_M]$ spanned the noise subspace, $\wedge = diag\{\propto_1, \propto_2, \cdots \propto_D\}$ and

$$\propto_1 \geq \propto_2 \cdots \geq \propto_D \geq \propto_{D+1} = \cdots = \propto_m = \propto_n^2 \quad (5)$$

The third step Based on the fact that the steering matrix is also spanned the signal subspace, the directions of arrival signals can be derived by finding the local maxima of the function

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$$D(\theta)\frac{1}{a^H(\theta)GG^Ha(\theta)} \qquad (6)$$

It should be pointed out that the curve is not the real spectrum of the signals across the angle range, but can reveal the existence in the direction domain.

VI. ALGORITHM FOR CLOSELY SPACE

MUSIC algorithm assumes that incoming signalsare uncorrelated. The covariance matrix Ruu is a non-singular matrix. The covariance matrix Ruu will lose its non-singularity property in case of the correlated signals. Thus the performance of MUSIC algorithm degrades severely in highly correlated signal

. Improved MUSIC involves modification of covariance matrix through a preprocessing scheme.ULA with M identical elements are divided into overlapping sub arrays of size p and introducing phase shift between these. Such that the array elements (0,., P-1) form the first subarray an (1, , p) form the second subarray.The vector of received signals at the kth forward subarrays is expressed as

$$x_k^F = AD^{(k-1)}s(t)n_k(t) \quad (7)$$

The spatial correlation matrix R of the sensor array is then defined as the sample mean of the covariance matrices of the forward sub-arrays:

$$R = \frac{1}{L}\sum_{k=0}^{L-1} R_k^F \qquad (8)$$

Here L is the number of overlapping sub-arrays. By applying spatial smooth MUSIC algorithm, M element sensor array can detect up to M/2 correlated signals

VII. SIMULATION RESULTS OF CLASSICAL METHOD

The MUSIC algorithm of DOA estimation is simulated using MATLAB. In these simulations, it is considered a uniform linear array antenna formed by elements with the equally spaced distance of the noise is Gaussian white noise, SNR=20dB and number of snapshots is 100. The simulation has been run for two independent angle of arrival is 20 and 30. The performance has been analyzed for different array elements and SNR.

Case.1: MUSIC spectrum for varying number of snapshots. As shown in Fig 2, as number of snapshots (N=1000) increases, Hence detection of incoming signals and Resolution capacity increases this is because increase the number of snapshots. If number of snapshot (N=100) then resolution of MUSIC algorithm decreases.

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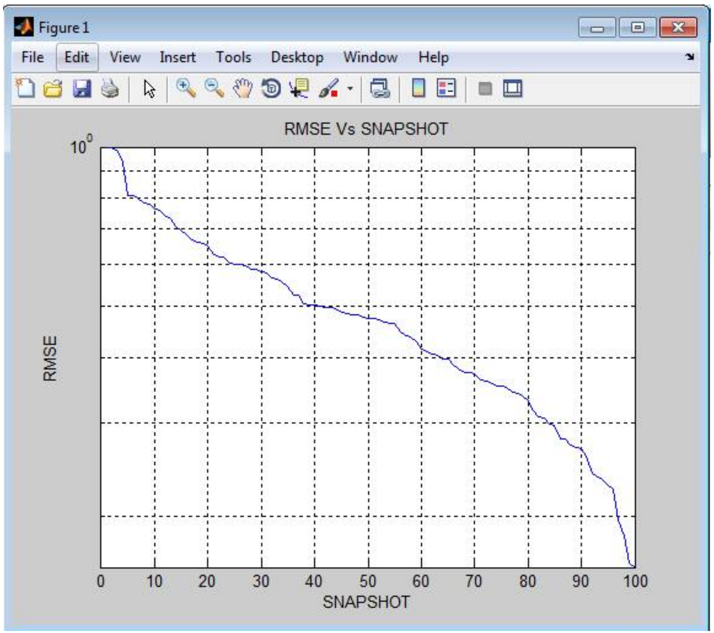

Fig2.MUSIC spectrum for varying RMSE VS Snapshot

Case.2: MUSIC spectrum for varying signal to noise ratio the effect of varying the signal to noise ratio with SNR= 2 and other condition remains unchanged are as shown in Fig 3. It is clear that as the value of SNR increases, precise detection of incoming signal. The value of SNR can affect the performance of the MUSIC algorithm

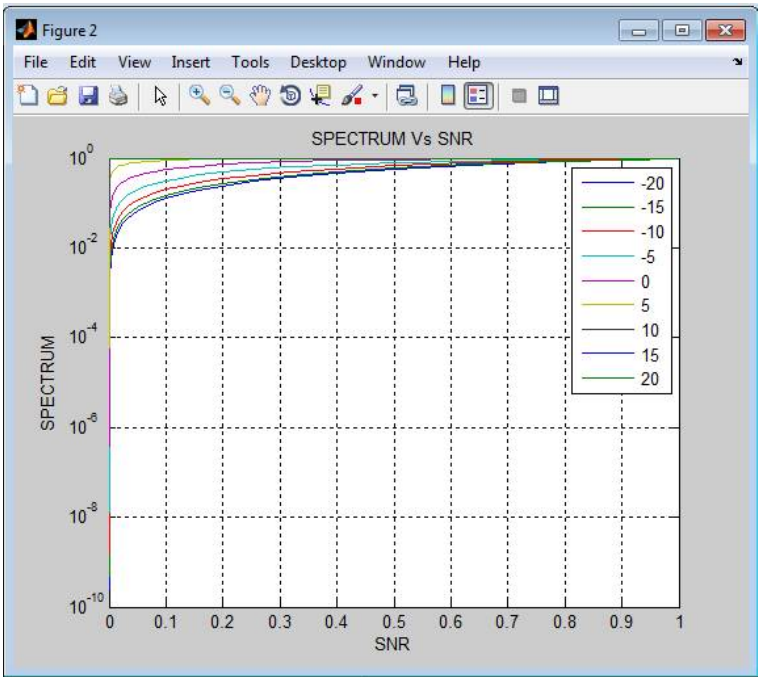

Fig 3. MUSIC spectrum for varying SNR

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Case 3: The SNR and accuracy are increased. We also assume that the impinging angles are from [20°, 22°], the number of snapshots is 100. The root mean square errors (RMSEs) in this paper are estimated from 300 independent realizations and the RMSE of the impinging direction of the i th (i =1, 2) signal is defined by

$$\sqrt{\sum_{j=1}^{300}[\acute{\theta}_i(j) - \theta_i(j)]^2/300} \qquad (9)$$

Where $\acute{\theta}_i(j)$ denotes the estimated value of $\theta_i(j)$RMSE performance for each angle is similar and so show the first one only.

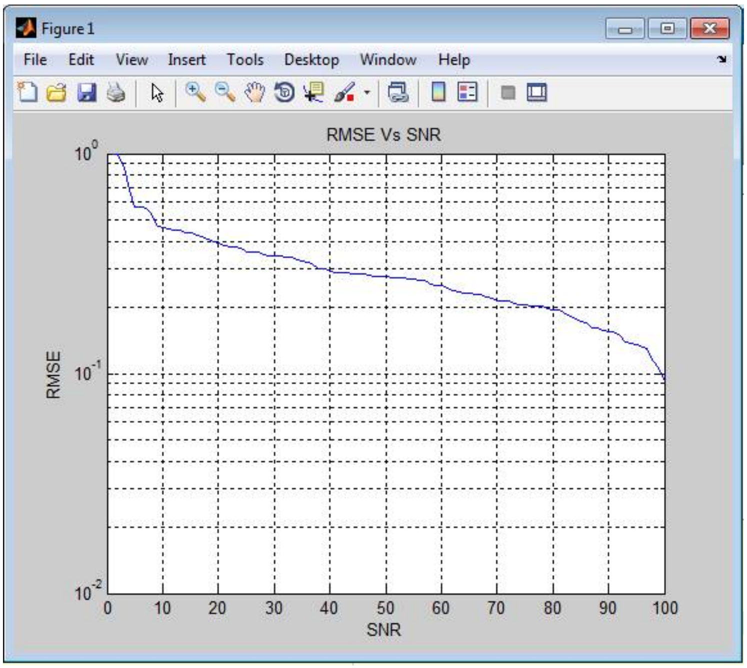

Fig.4 MUSIC spectrum for varying RMSE VS SNR

Fig 4 reveals the varying RMSE vs SNR for MUSIC algorithm. In low SNR,the accuracy MUSIC algorithm is superior to classical MUSIC algorithm. In relative high SNR, both can resolve the closely spaced signals and accuracyof MUSIC algorithm.

VII. CONCLUSION

In this paper we presented closely space signal using MUSIC and Modified MUSIC algorithm. The simulation result of MUSIC algorithm shows that angular resolution of MUSIC algorithm improves with more no. of elements in the array, with large snapshot of signals. Music can estimate uncorrelated signal very well. Improved MUSIC estimates accurate DOA of signal under coherent condition.

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